ViP2P: XML Warehousing in P2P Networks

Ioana Manolescu, Spyros Zoupanos

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Equipe Leo
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Supported by: *ANR-08-DEFIS-004 CODEX, INRIA ADT ViP2P & ViRDF*

Leo and friends in front of our lab

Part I

Introduction

Motivation

Distributed data management: old goal (1970)

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- distributed versions of industrial-strength DBMSs
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Still missing: the flexible federation

- high independence of the sites: when to be in, what to store
- data distribution transparency
- . . . with the usual performance requirements

Distributed warehouses of Web content

Web content

structured documents, schemas, annotations, concepts, mappings, Web services, inter-document links

Web content warehouse

Distributed database of selected content, whose users may:

- publish resources
- connect (annotate, map, link...) existing resources
- update resources
- enhance resources by combining them

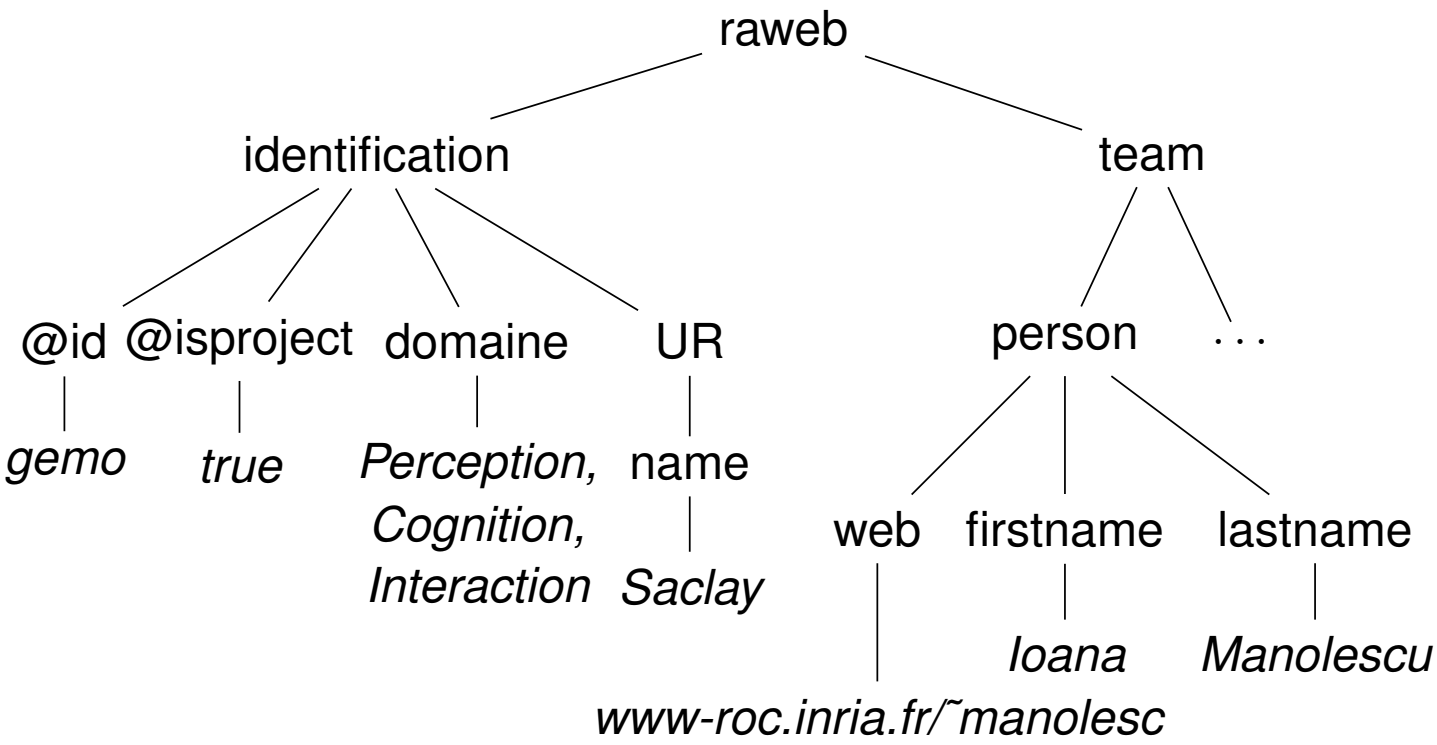
In the style of the RNTL WebContent project (2005-2009)

INRIA annual activity report in XML

https://irabot.inrialpes.fr/RA2009/gemo.xml

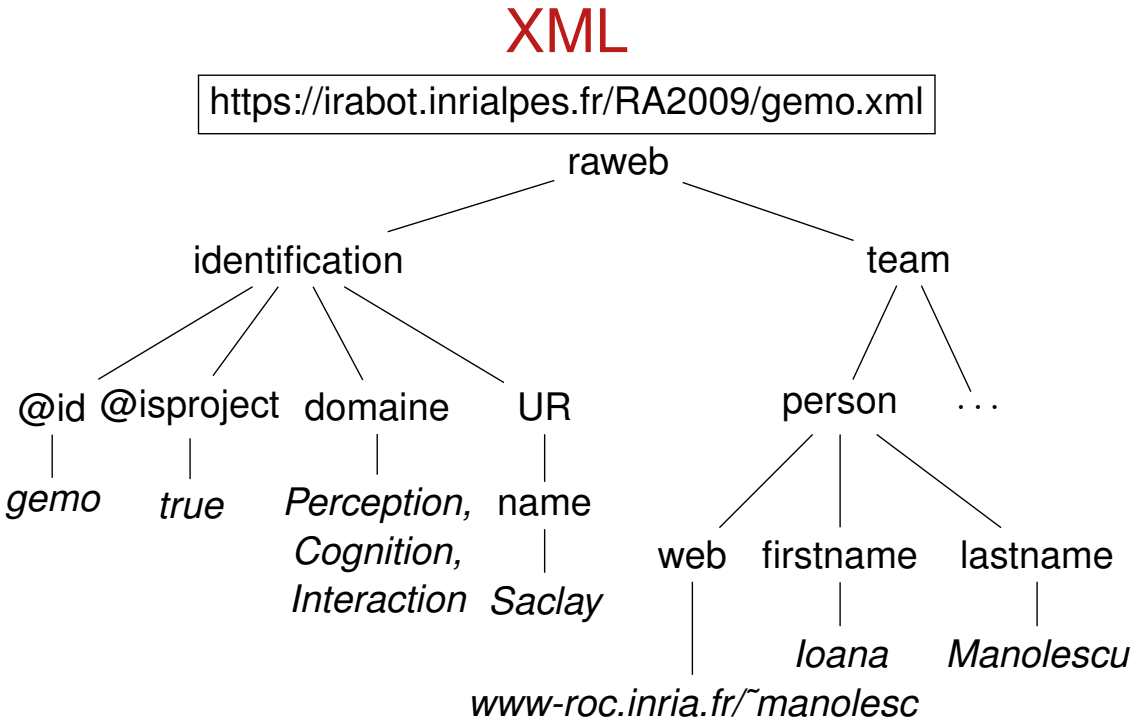
```
<?xml version="1.0" encoding="iso-8859-1"?>
<!DOCTYPE raweb PUBLIC "raweb2.dtd">
<raweb year="2009">
  <identification id="gemo" isproject="true">
    <shortname>gemo</shortname>
    <domaine>Perception, Cognition, Interaction</domaine>
    <UR name="Saclay"/>
  </identification>
  <team>
    <person>
      <web>http://www-roc.inria.fr/~manolesc</web>
      <firstname>Ioana</firstname>
      <lastname>Manolescu</lastname>
    </person>...
  </team>...
</raweb>
```

INRIA annual activity report in XML



- (Very) popular data exchange format
- Many W3C standards + efficient tools

XML and the Semantic Web



RDF

http://gemo.saclay.inria.fr
wroteReport
https://irabot.inrialpes.fr/RA2009/gemo.xml

---

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http://codex.saclay.inria.fr

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http://codex.saclay.inria.fr
hasType
http://www.inria.fr/types.xsd#ContratFR

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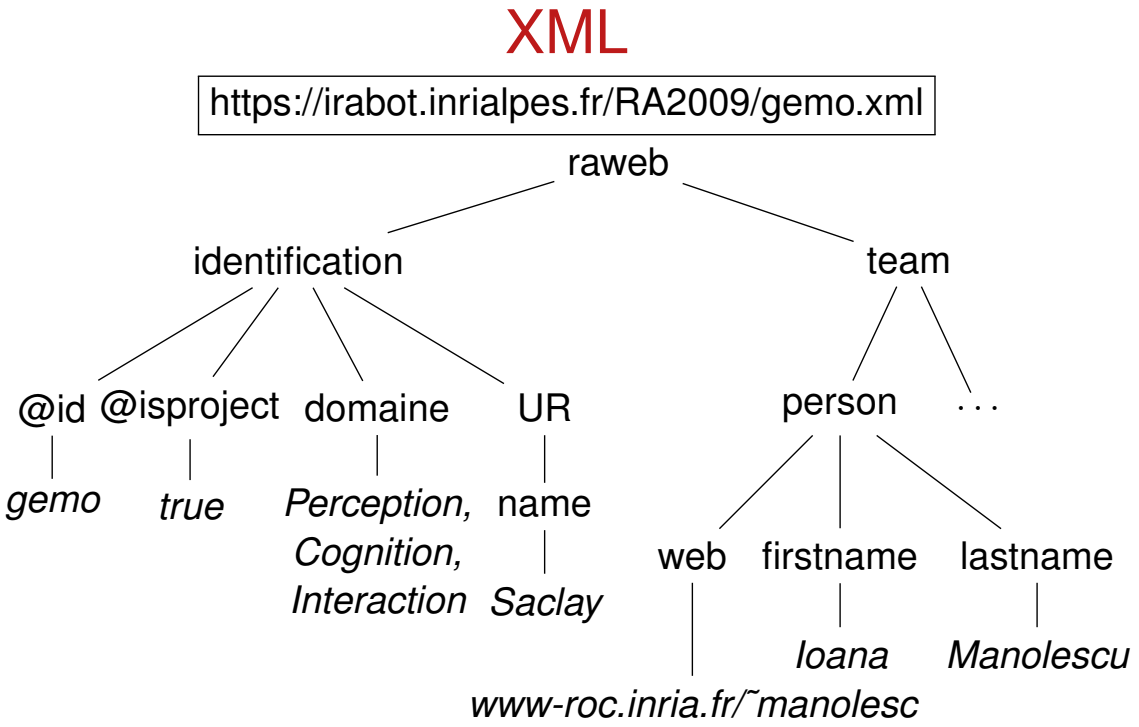

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---

http://codex.saclay.inria.fr
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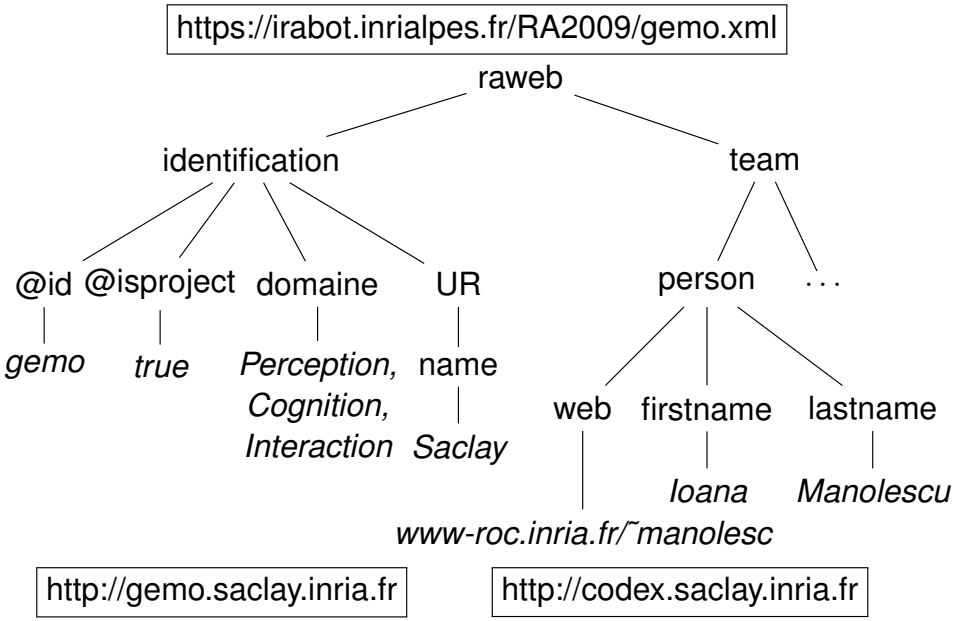
Possible queries

- European projects involving at least two INRIA teams?
- Most frequent keywords for each INRIA theme?
- PhD students co-supervised with a foreign University?

Distributed warehouses of Web content

Distributed XML



http://gemo.saclay.inria.fr

http://codex.saclay.inria.fr

Distributed RDF

Serv. Inf. Sci. Tech. INRIA	http://pierre.senellart.com *collaboratesWith* https://gemo.saclay.inria.fr
Indiana Univ.	http://pierre.senellart.com *coordinates* dbweb.enst.fr/events/sigmod10contest/
Splitted Desktop	http://gemo.saclay.inria.fr *possibleCollaborator* http://www.splitted-desktop.com/fr/

Distributed warehouses of Web content

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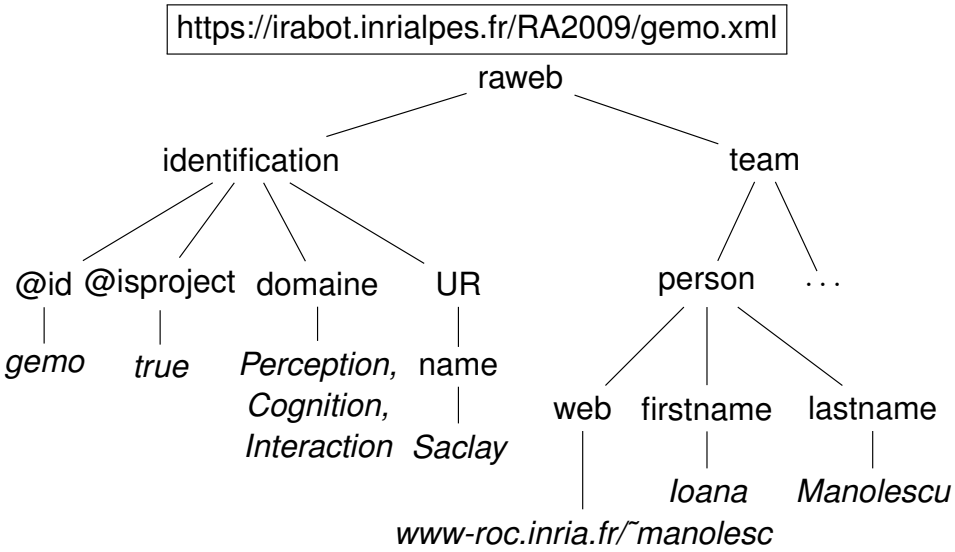

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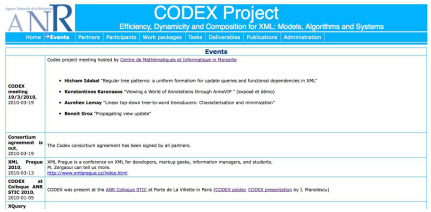

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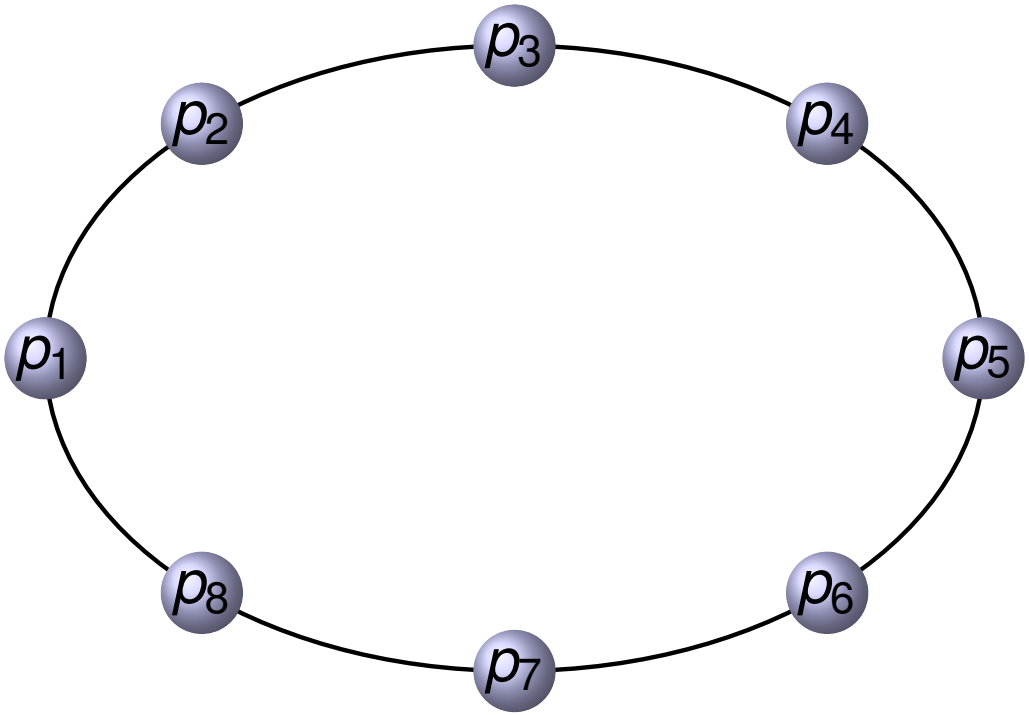
- French researchers involved in ACM conference organization?
- Possible collaborators for a data management project in the clouds?

Distributed hash tables



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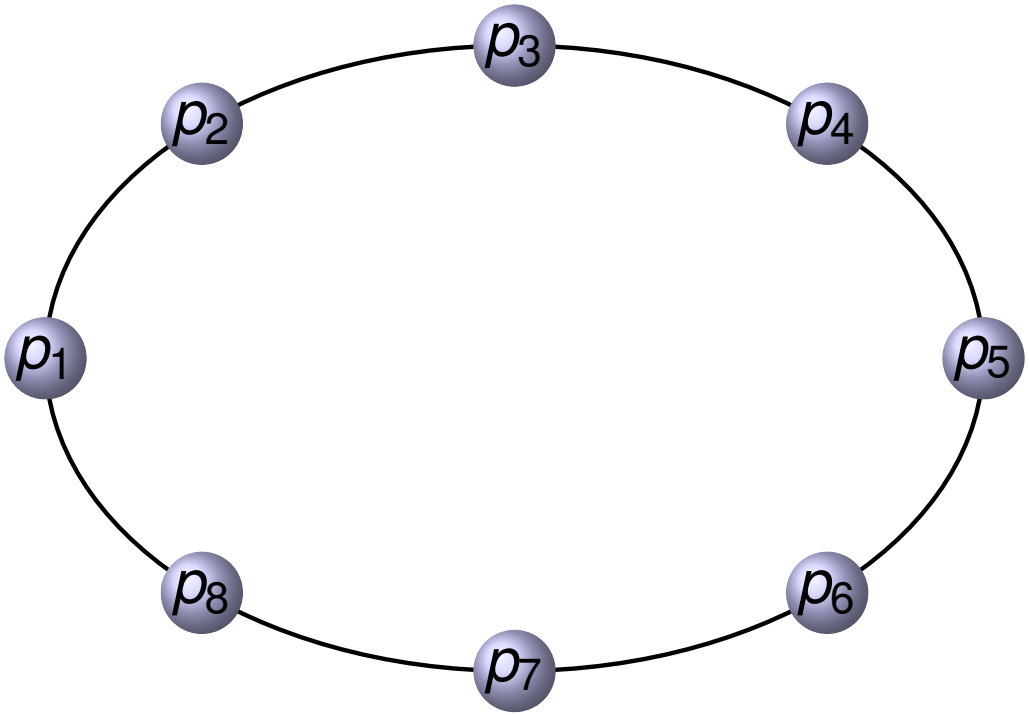

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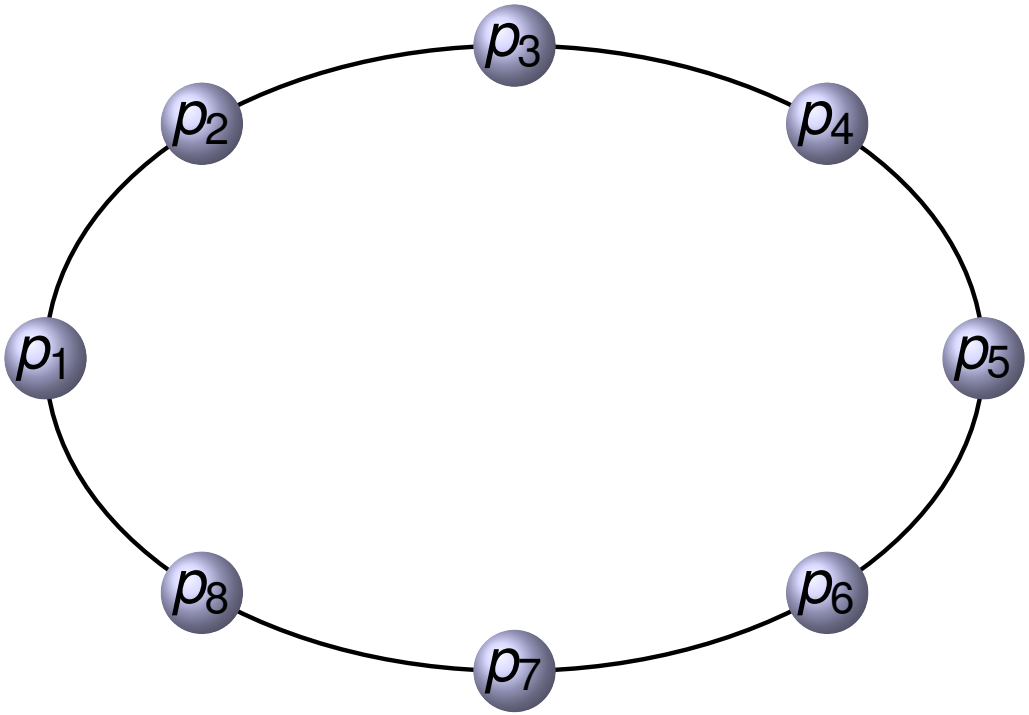

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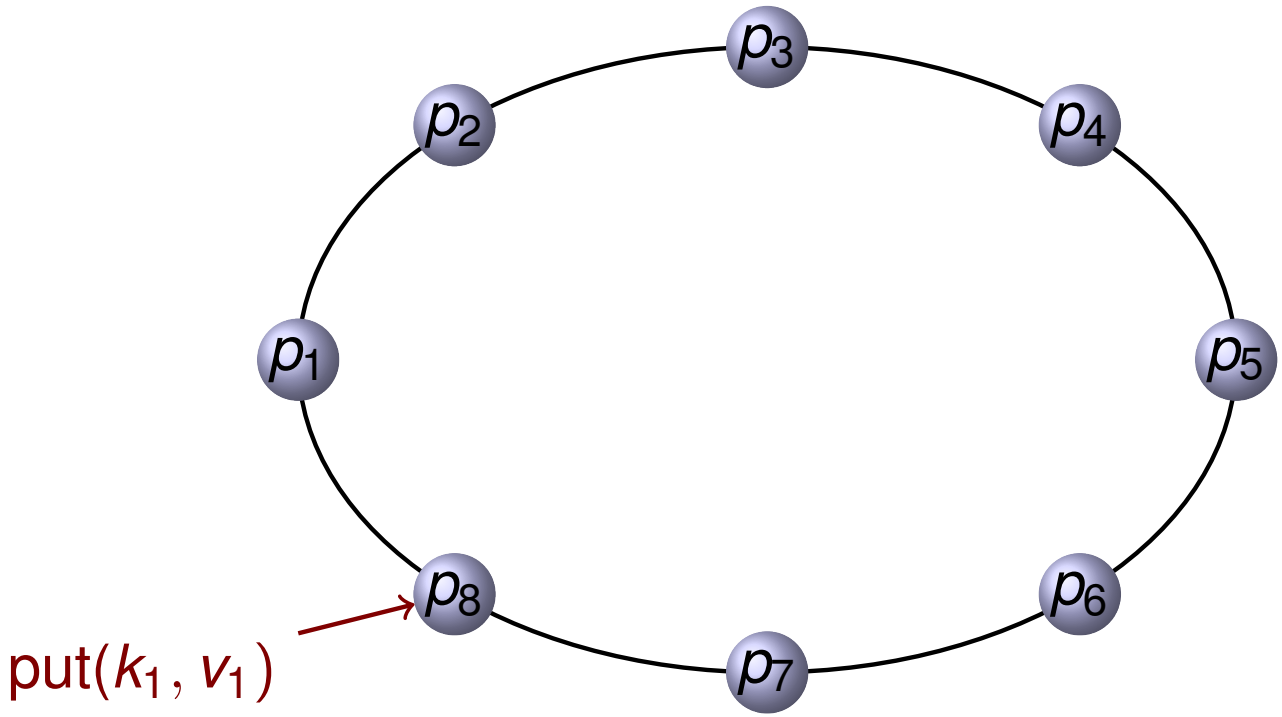

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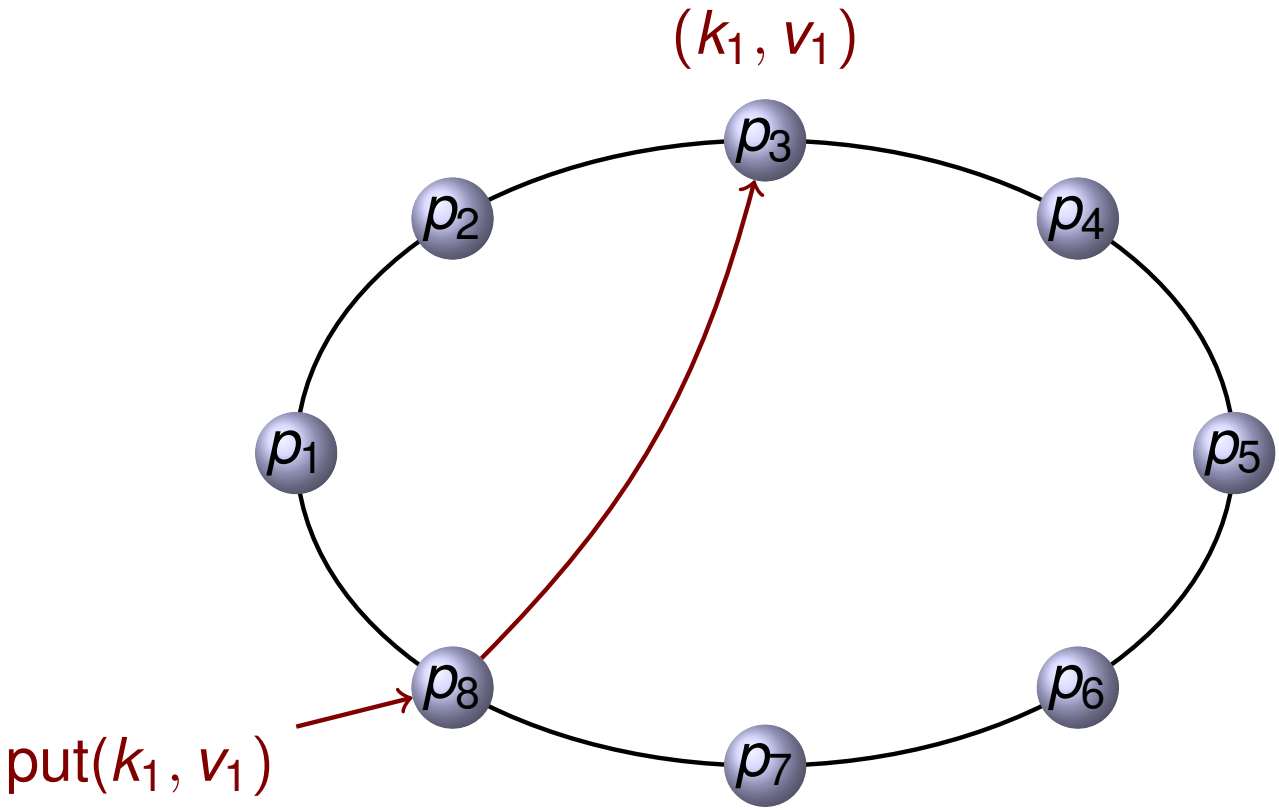

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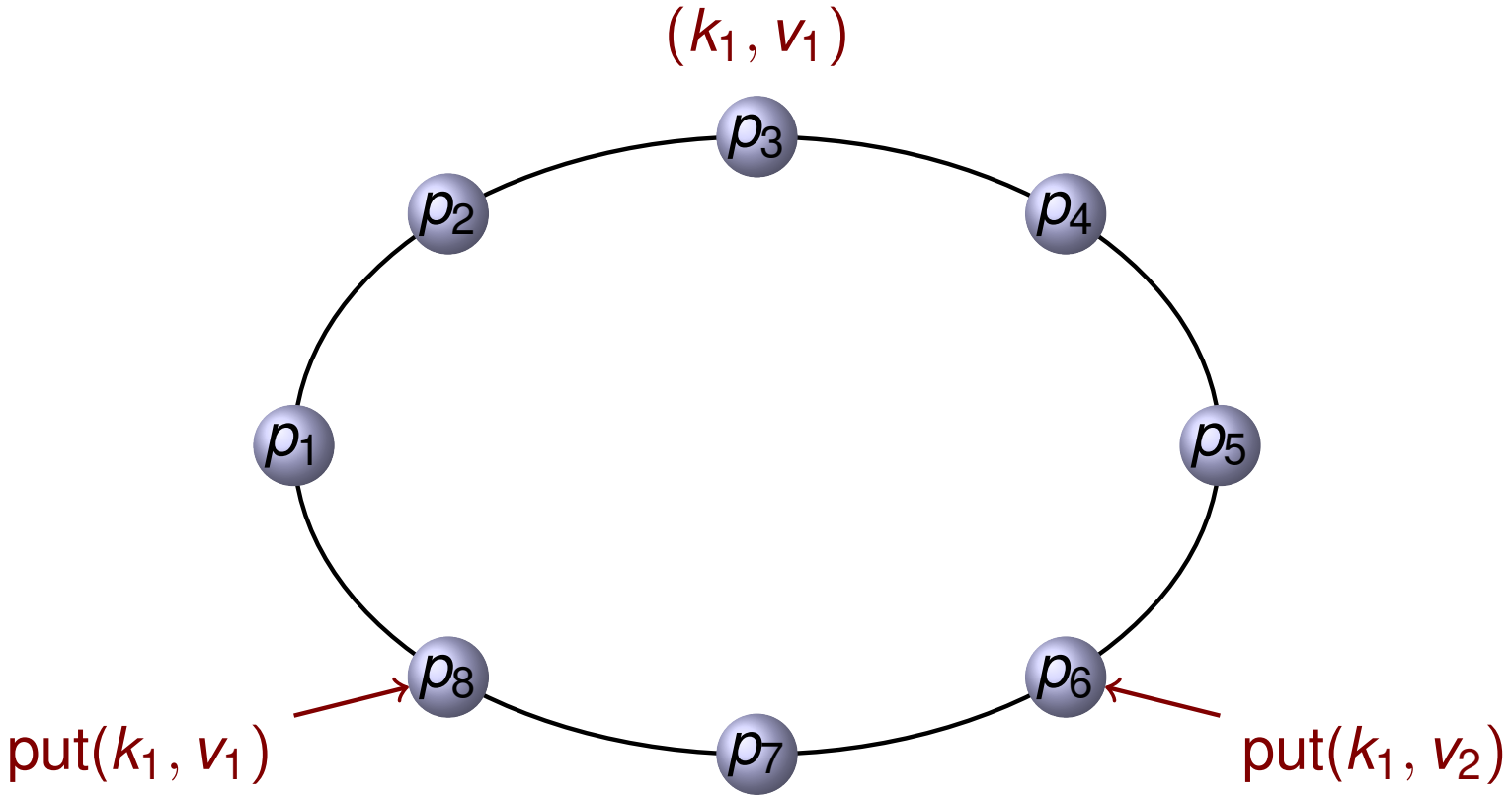

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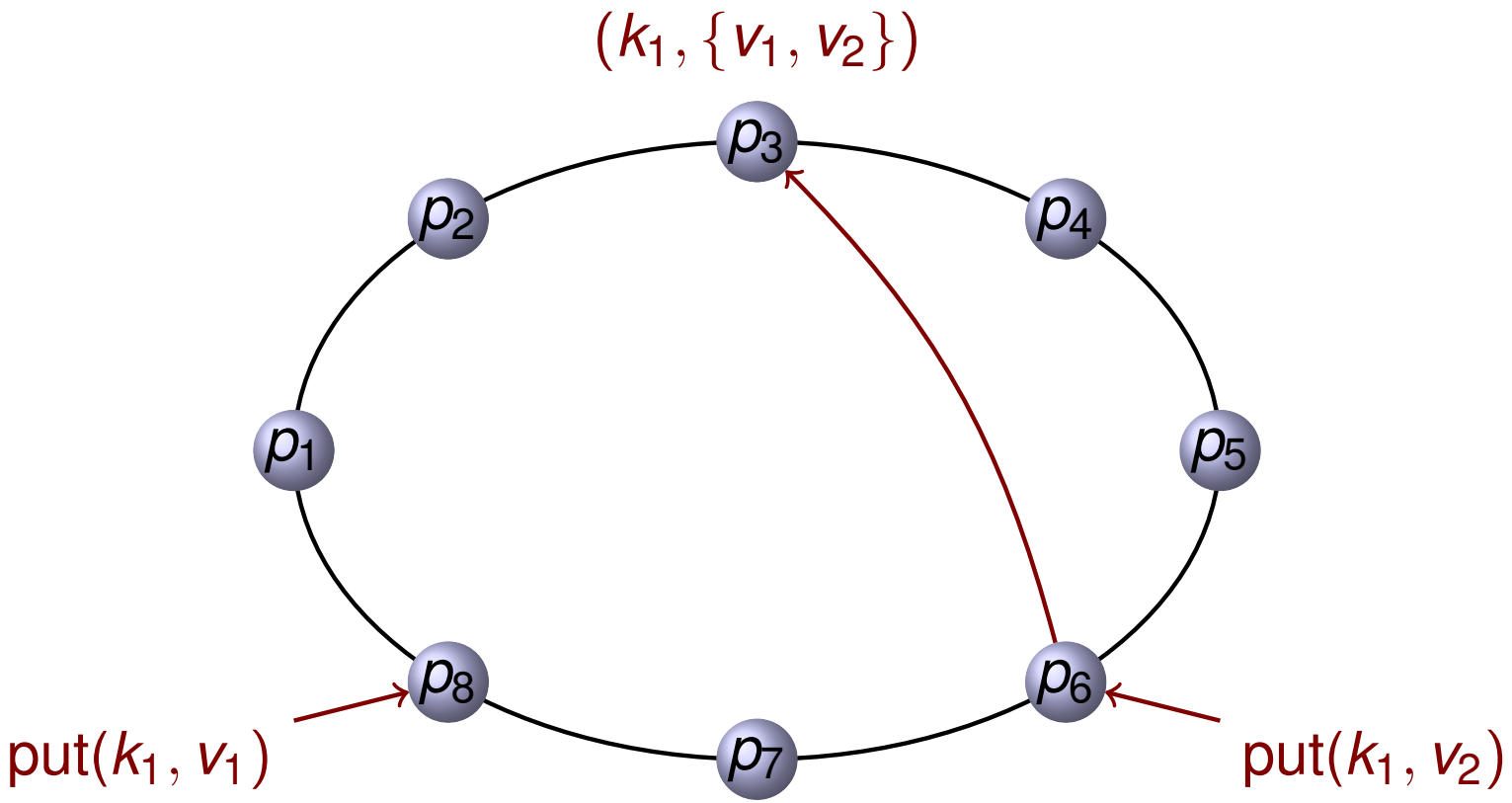

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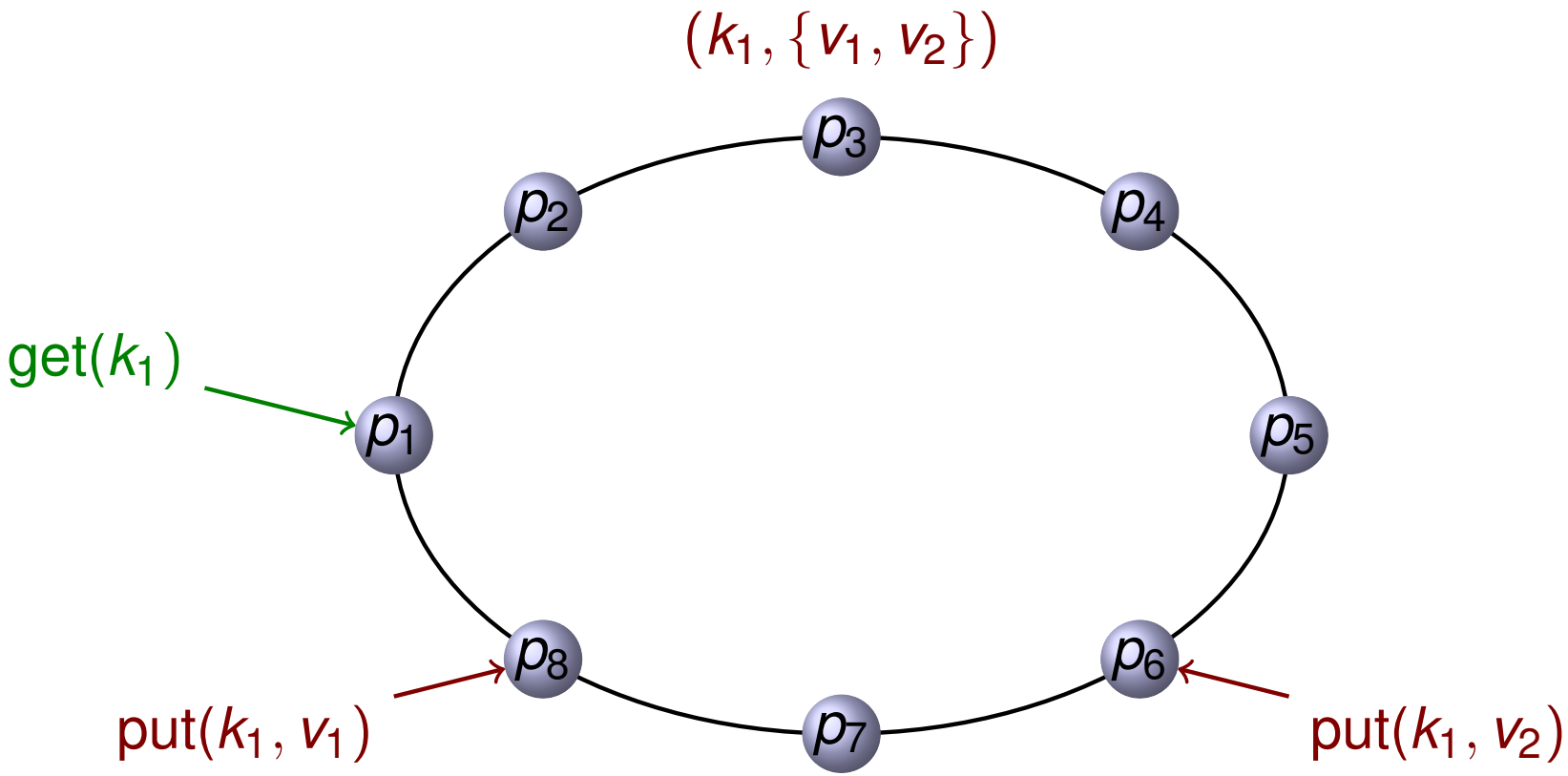

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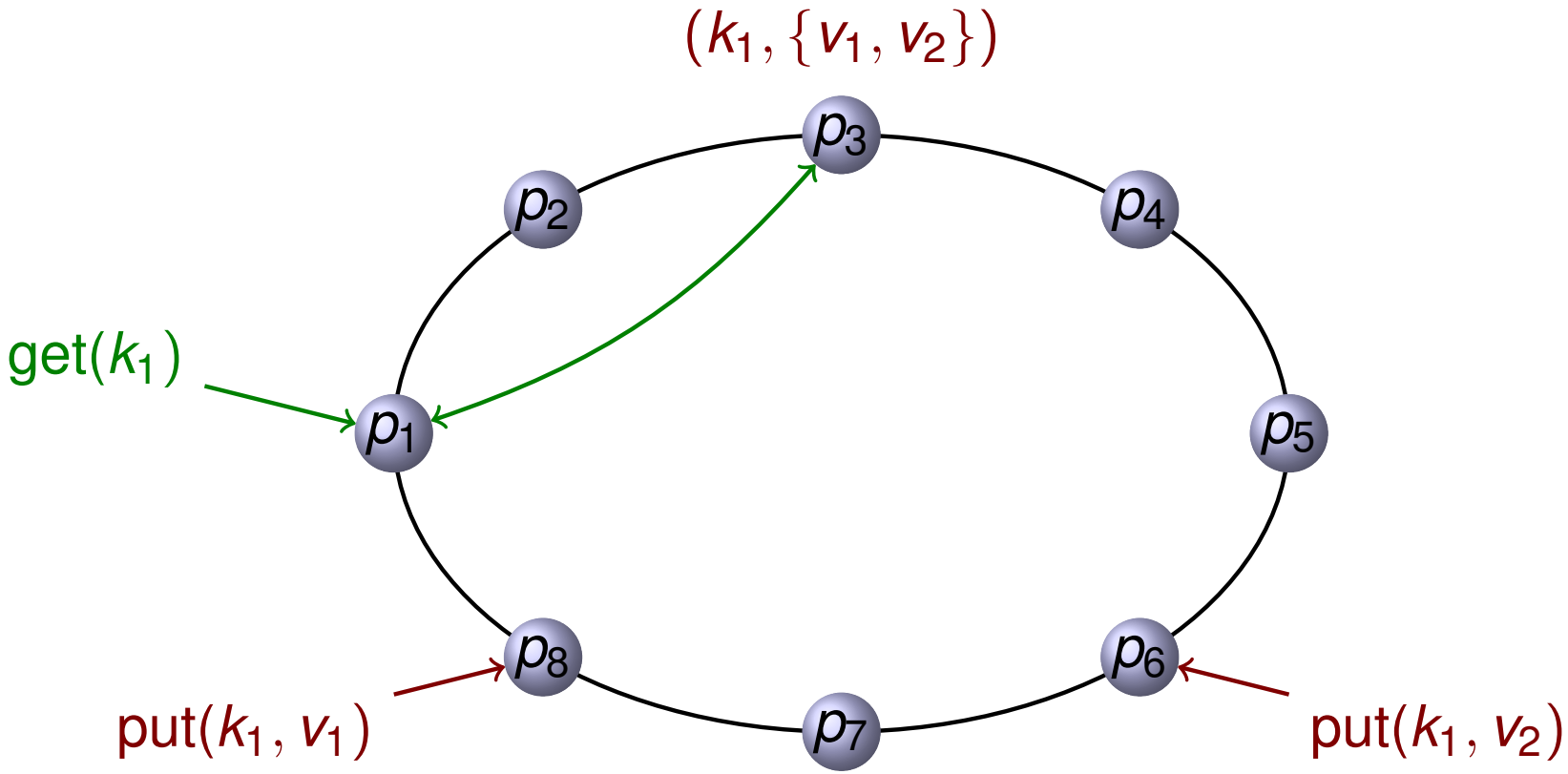

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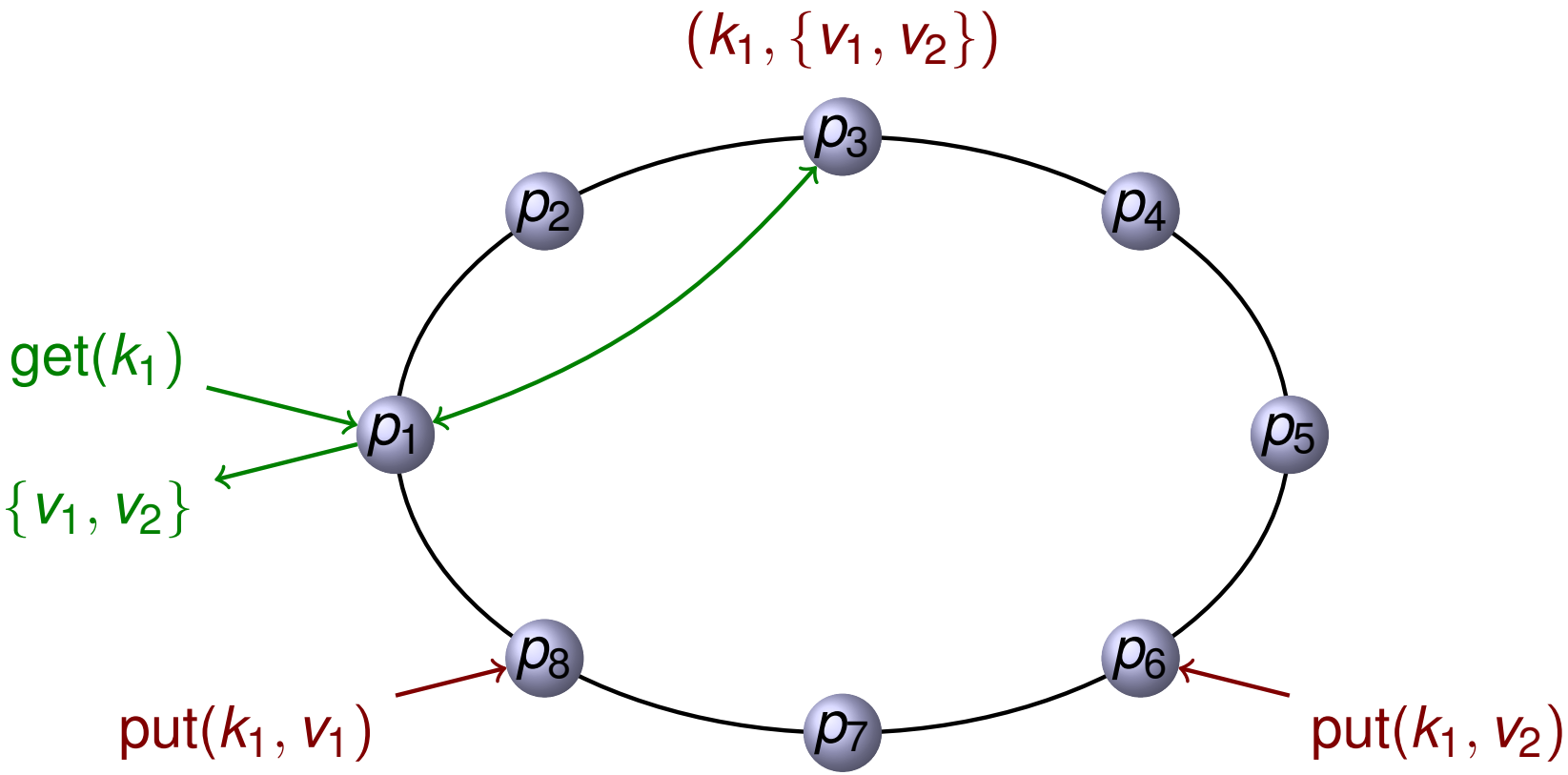

What distributed hash tables provide

Dynamic peer networks

- each peer is assigned an id $\Rightarrow$ address range
- bound of $log_2(N)$ hops to route a message to peer
- network re-adjustment when peers join or leave: peers' address spaces stretch and contract

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(Key, value) stores = basis for content sharing

- index the resources by keys
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Main DHT functionality

Small shared memory $\Rightarrow$ resource catalog

From DHTs to distributed data management

Functionalities to add

- data indexing
- storage for application data and even DHT index data
- local query processing
- distributed query processing: operators, including data transfers, optimization . . .

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Reliability

provided	a peer will eventually answer at each address some (key, value) replication to handle peer failures (broadcast to k replicas)
to do	resilience of all added functionalities to peer joining/leaving/failing

Querying distributed data on a DHT

Two types of operations:

1. Look up useful data sources in the DHT
   - Documents matching the query
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   Distributed query processing “as usual”

Trade-offs in DHT indexing and query processing

Level of detail of resource indexing

- lookup precision $\nearrow \Rightarrow$ execution time $\searrow$
- data publication time $\nearrow$, possibly execution time $\nearrow$

Data re-placement or clustering

- fewer peers contacted for a query (message no. $\searrow$, execution time ?)
- data transfers in the absence of queries (message no. $\nearrow$, total message size $\nearrow$)

Part II

ViP2P: materialized views on DHTs

Joint work with

Students

- Konstantinos Karanasos, Asterios Katsifodimos, Spyros Zoupanos (PhD 2009)
- Martin Goodfellow (U. Strathclyde), Silviu Julean (UVT, Romania), Varunesh Mishra (IIT Kanpur), Alexandra Roatis (UVT, Romania)

Engineers

Jesús Camacho-Rodriguez, Julien Leblay, Alin Tilea

Friends from abroad

Angela Bonifati (CNR Italy), Vasilis Vassalos (AUEB, Greece)

Web data sharing in ViP2P

Web data:

- XML documents
- RDF annotations

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Choices:

Web data sharing in ViP2P

Web data:

- XML documents
- RDF annotations

Choices:

- peers retain control over the data they store/publish
  - no global schema
  - documents published independently
  - annotations (triples) can freely connect content
- content is re-distributed: peers may accumulate results of long-running queries
- peers share their accumulated results with others

Behind the scene: distributed materialized views

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Long-running query = subscription = view

Declarative specification of results that the peer is interested in

- tree pattern $\Rightarrow$ matches an individual document
- tree patterns with value joins $\Rightarrow$ matches across distinct documents
- corresponding XQuery dialect

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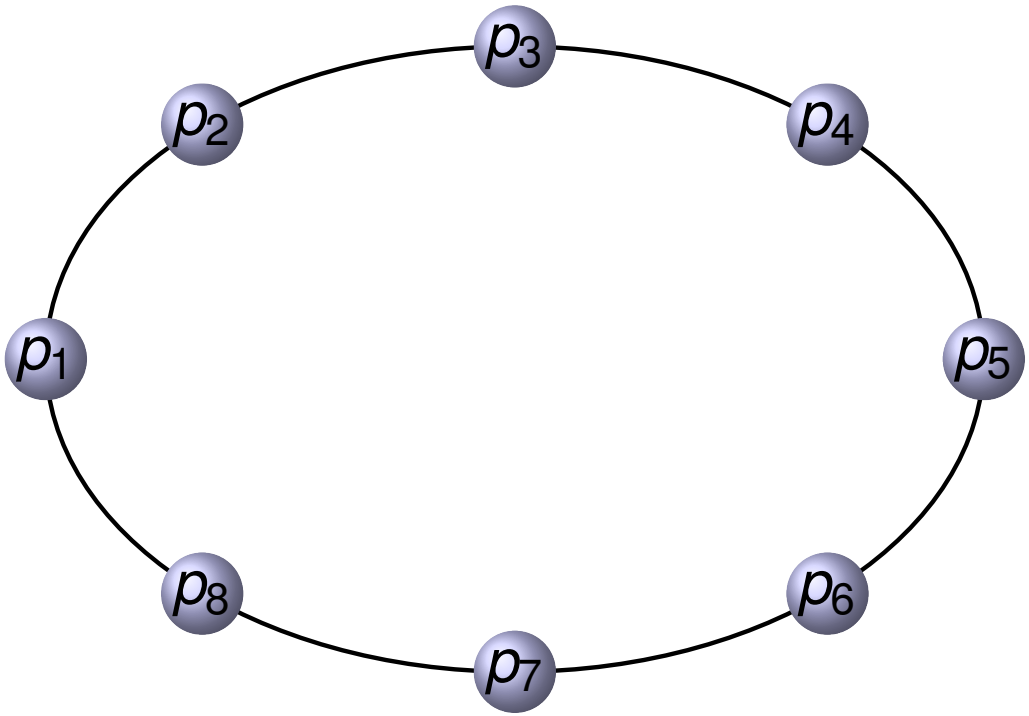
Find relevant views ⇒ rewrite the query ⇒ optimize the rewriting

Query execution = distributed query processing

With XML- and RDF-specific bells & whistles

Publishing and querying in ViP2P



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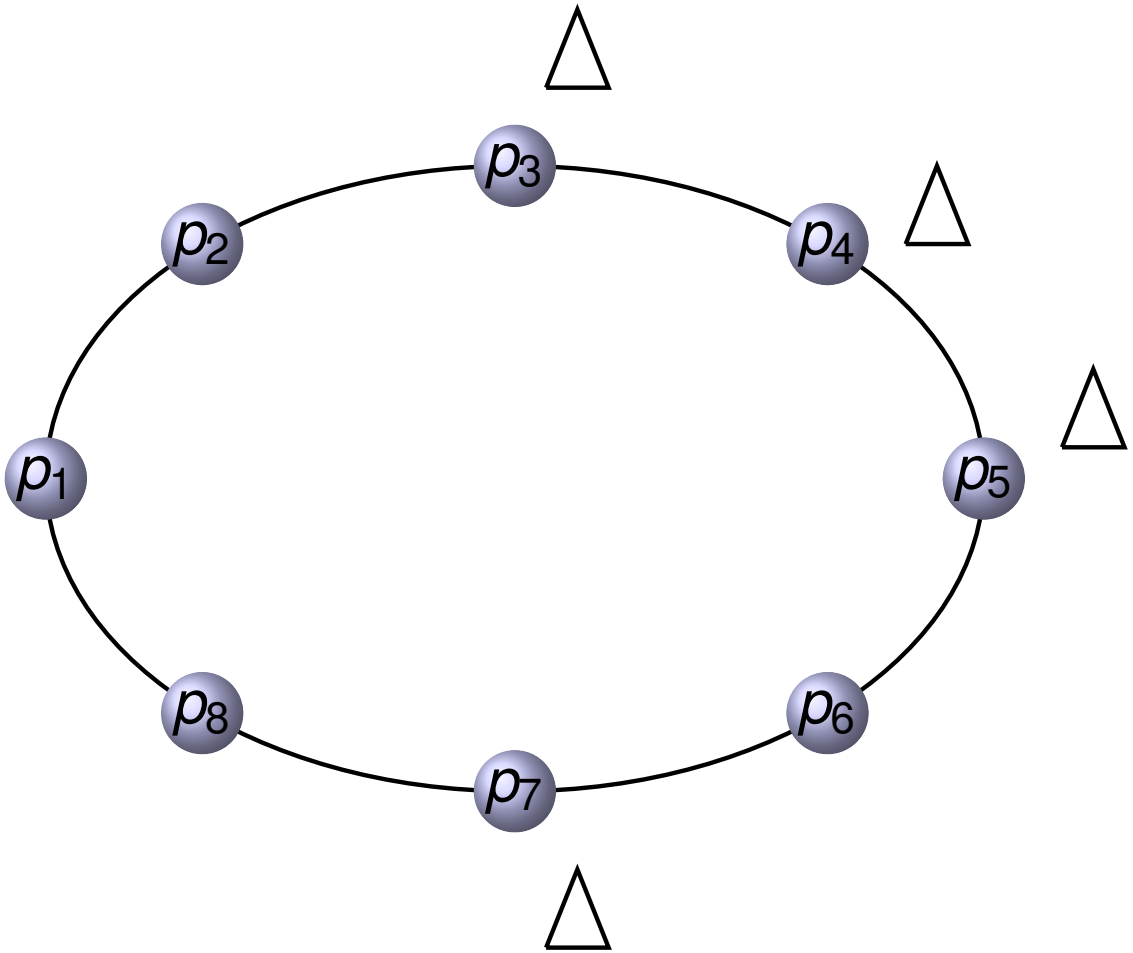

The peers may store:

- documents, annotations

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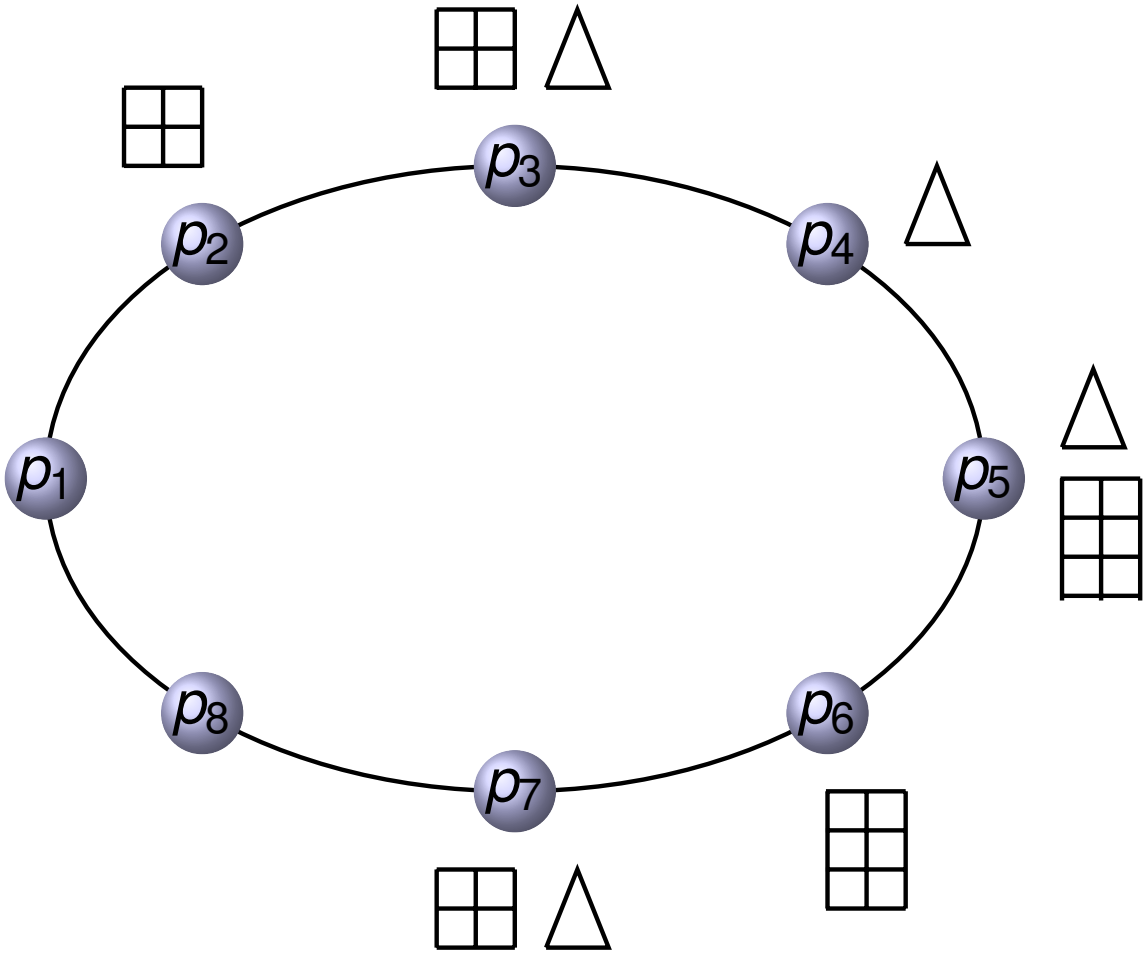

The peers may store:

- documents, annotations
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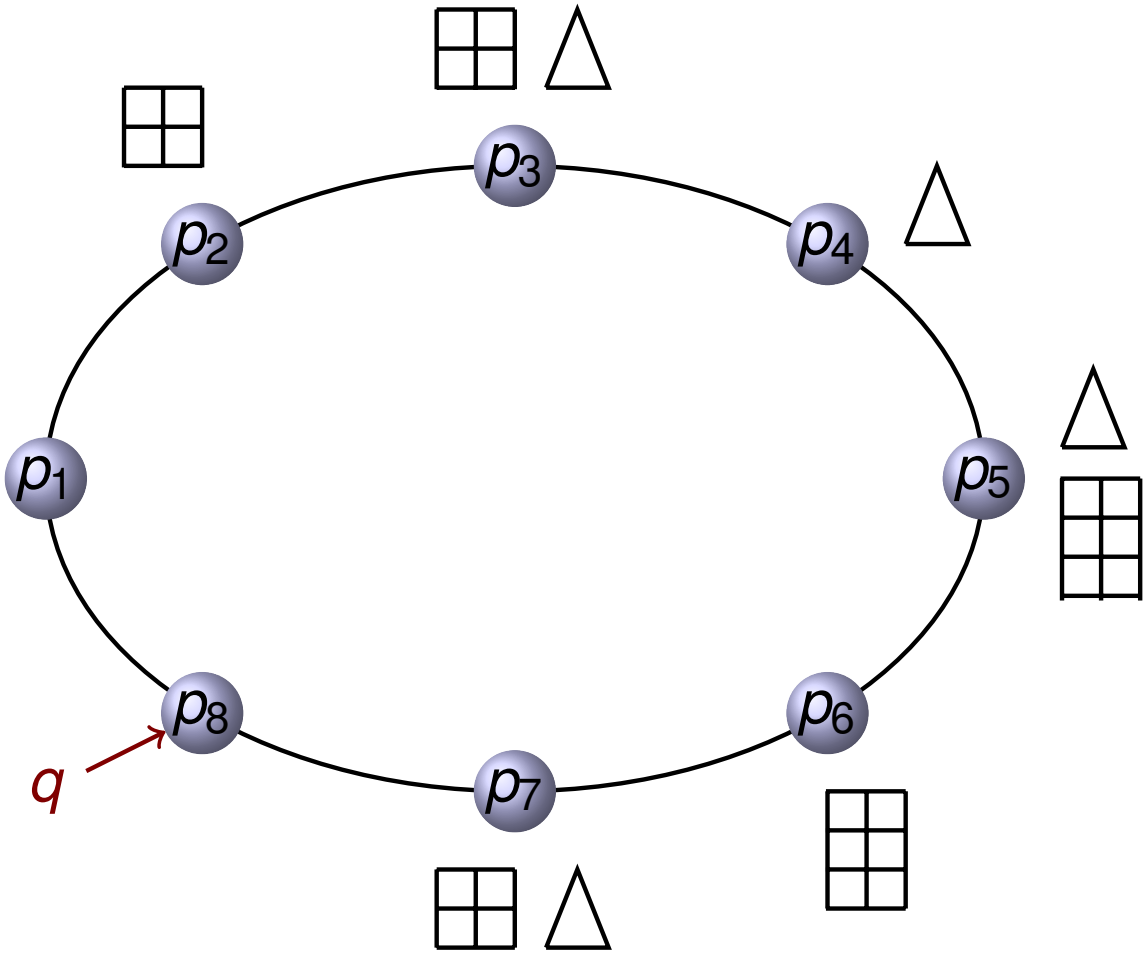
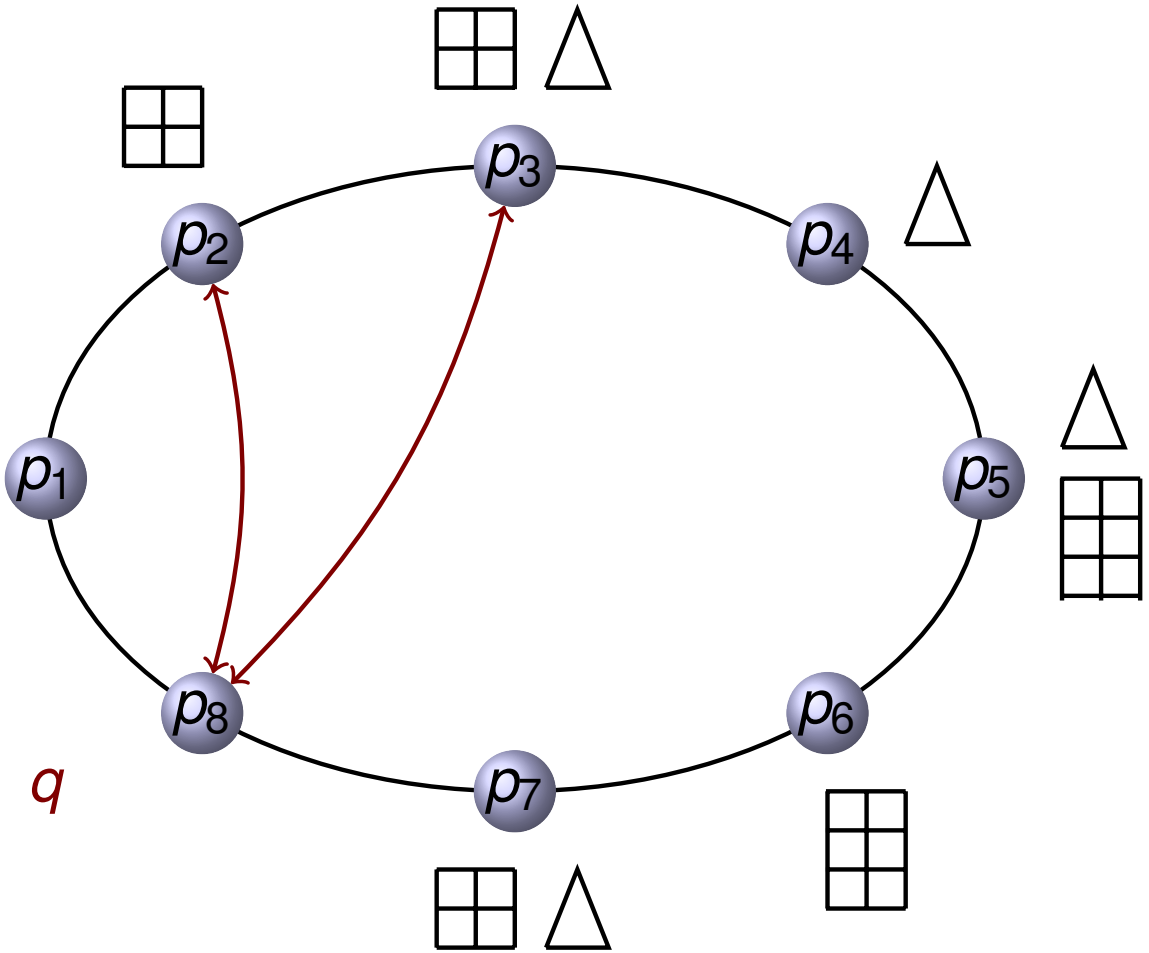


When q arrives:

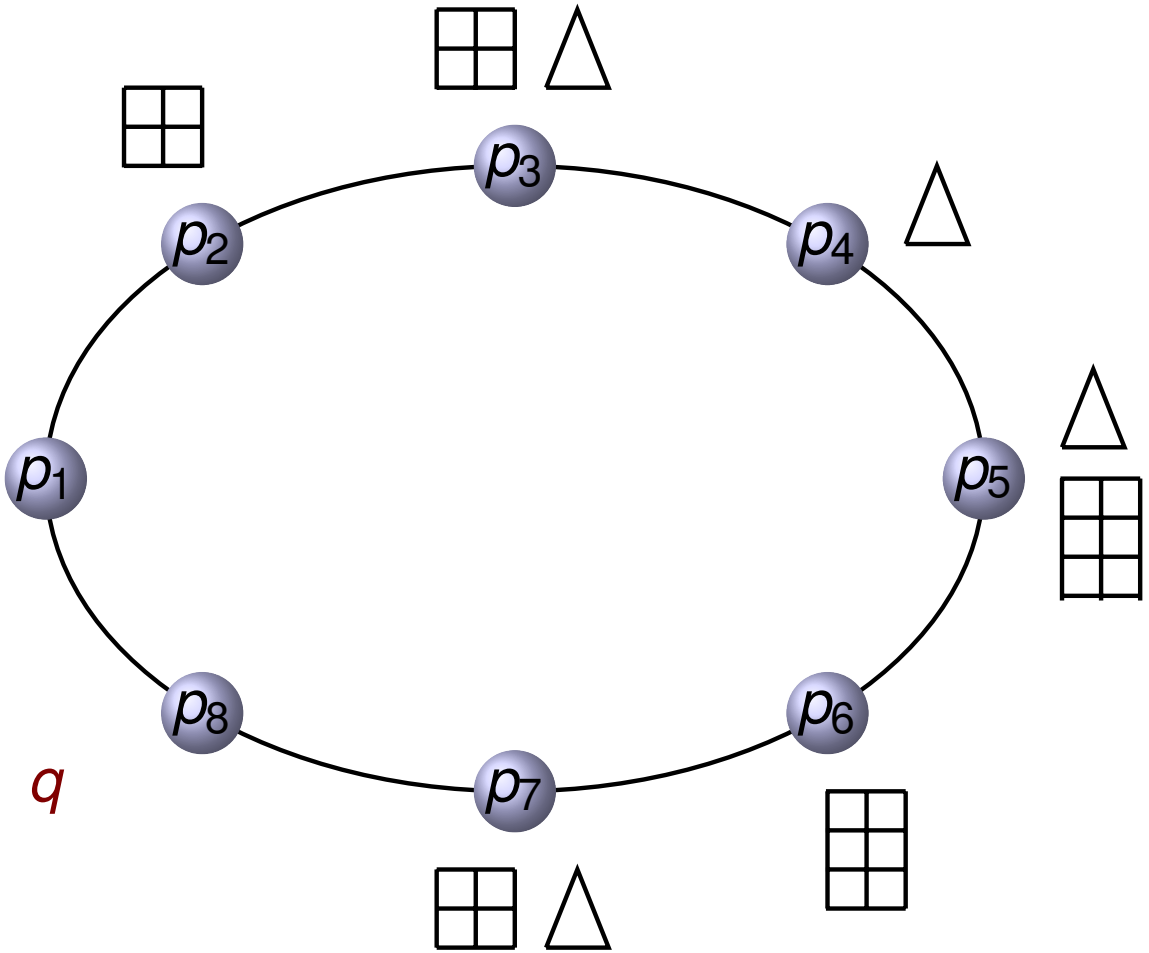
Publishing and querying in ViP2P



When q arrives:

- view definition lookup

Publishing and querying in ViP2P



When q arrives:

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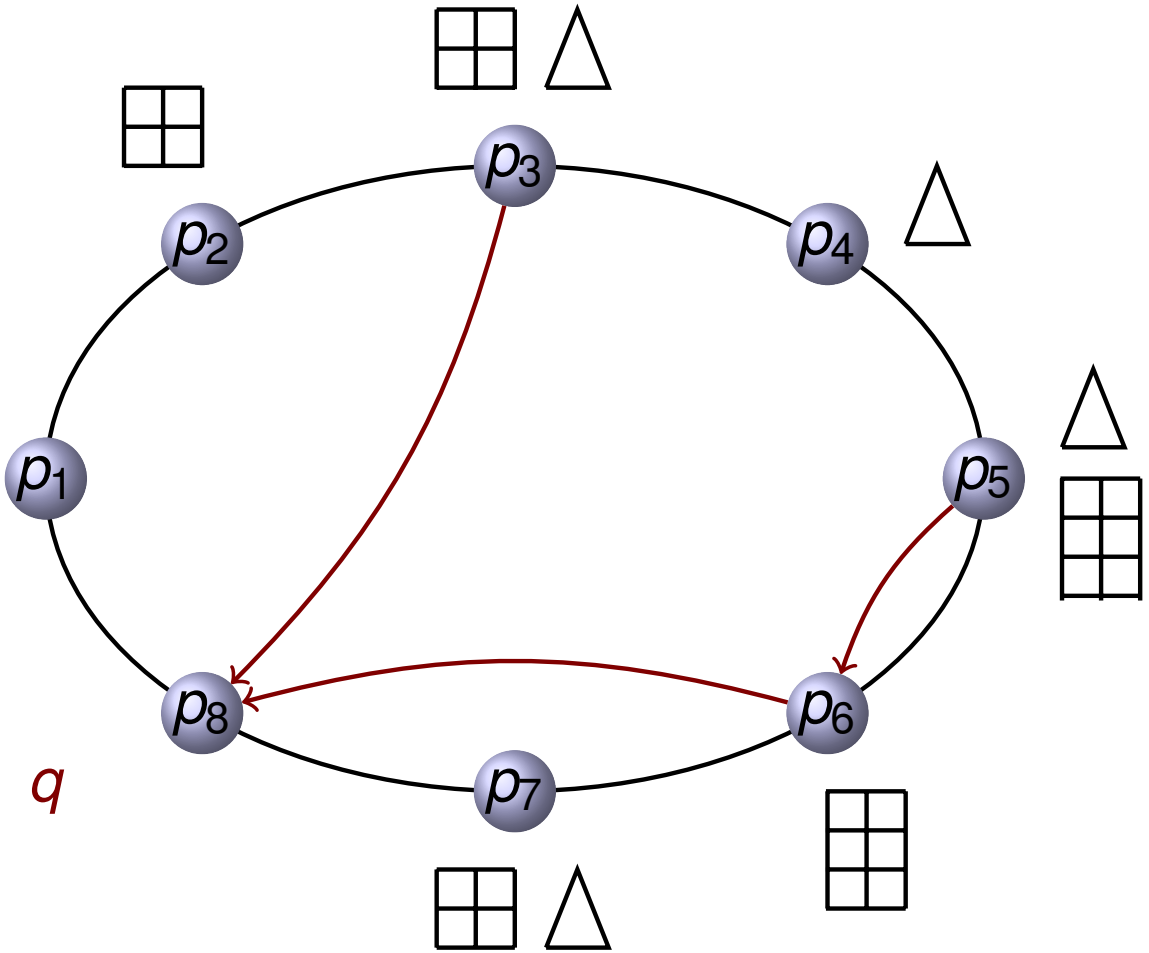
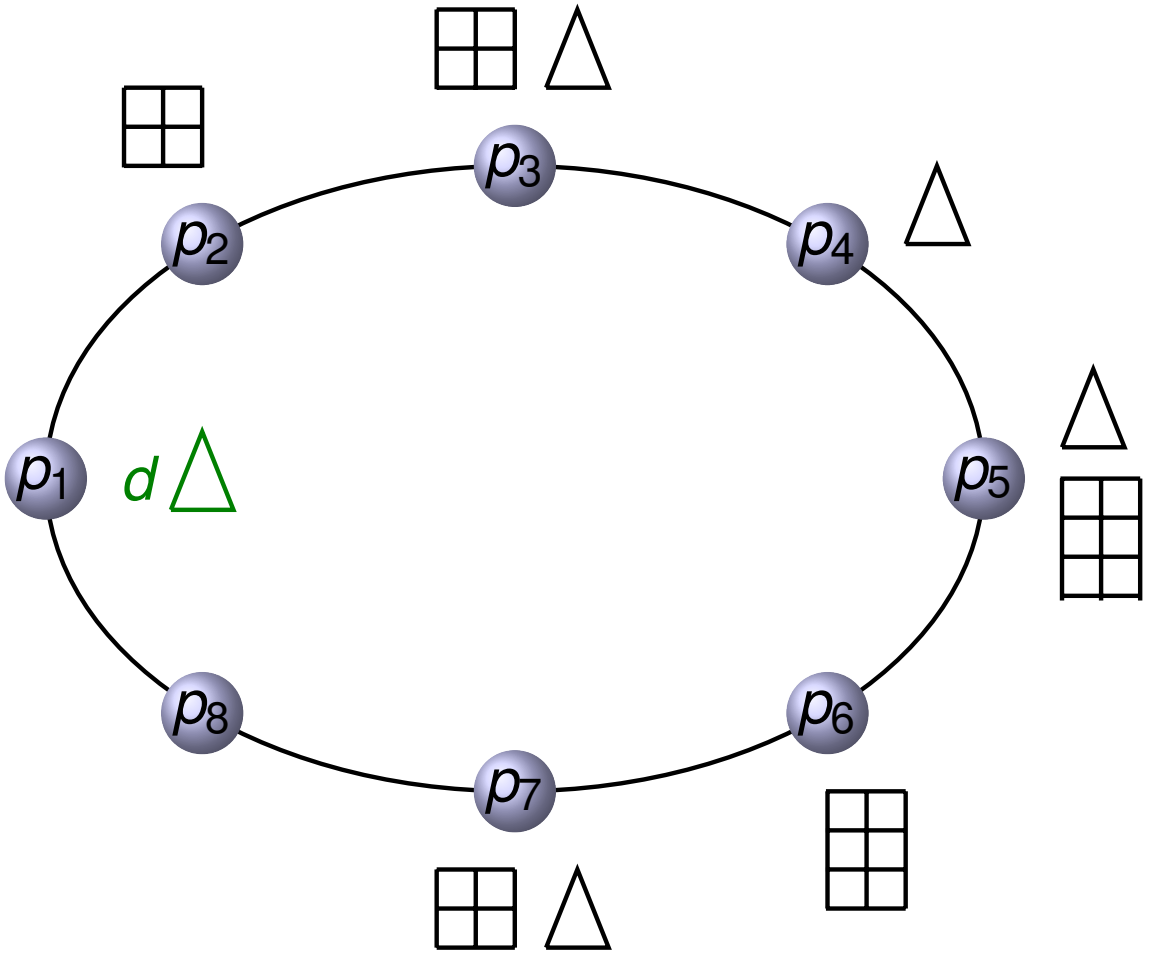
Publishing and querying in ViP2P



When q arrives:

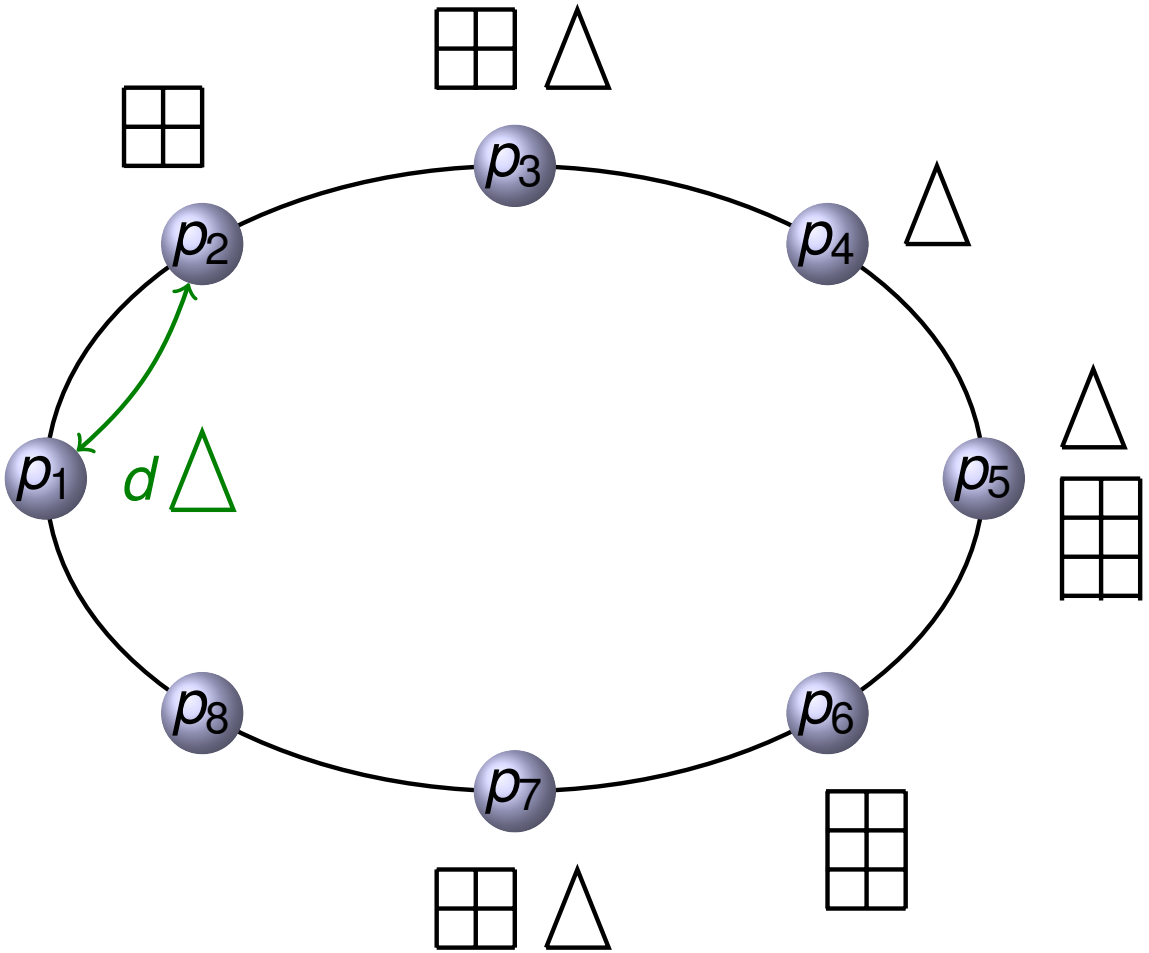
- view definition lookup
- rewriting
- execution of physical plan

Publishing and querying in ViP2P



When *d* arrives:

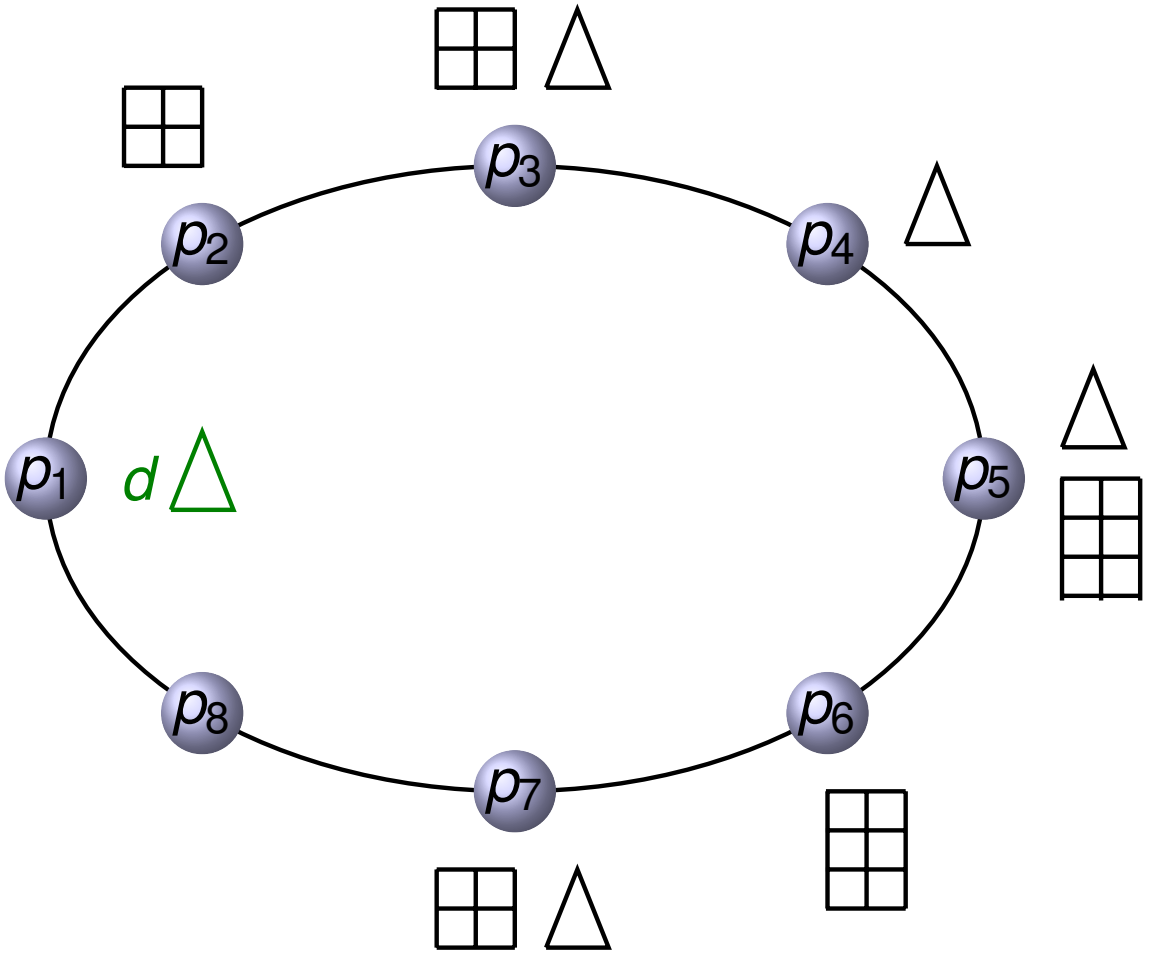
Publishing and querying in ViP2P



When d arrives:

- search view definitions for which $v_i(d) \neq \emptyset$

Publishing and querying in ViP2P



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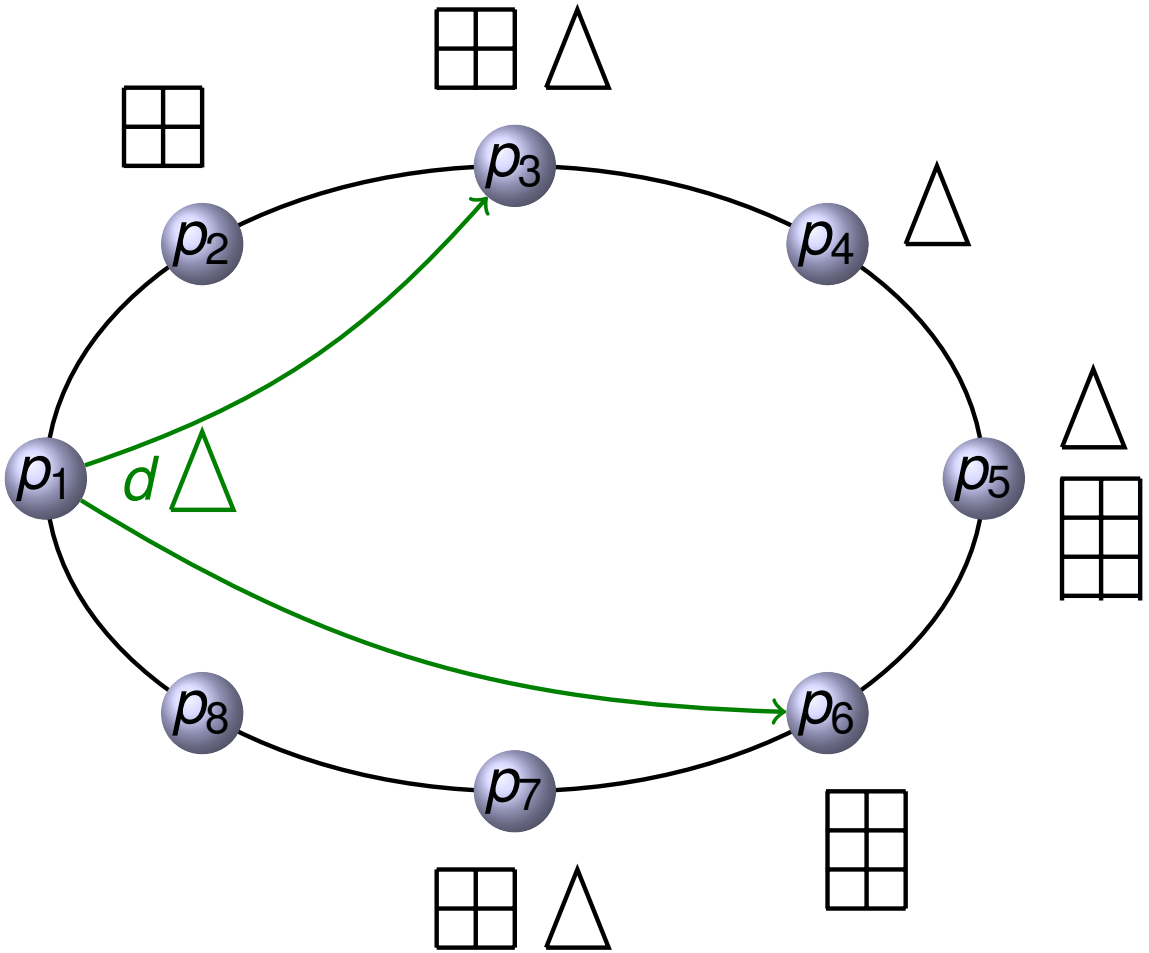
Publishing and querying in ViP2P

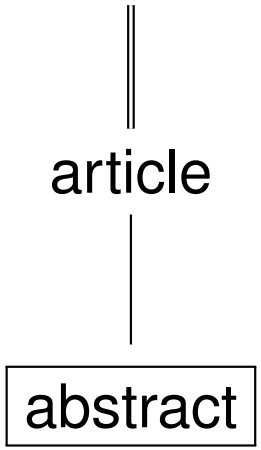


When d arrives:

- search view definitions for which $v_i(d) \neq \emptyset$
- compute $v_i(d)$
- send results

Sample views

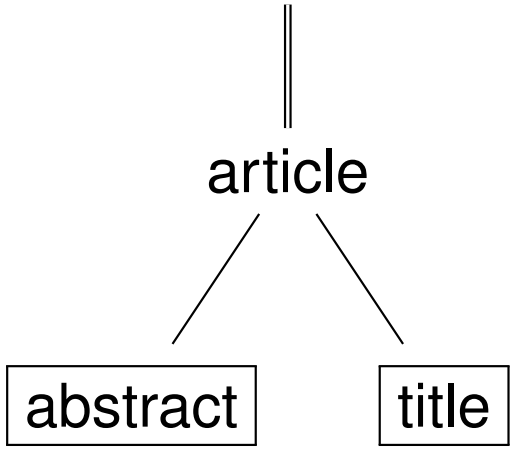
All article abstracts



URI	abstract
http://peer1.com/doc1.xml	Databases. . .
http://peer2.com/f2.xml	XML processing. . .
. . .	. . .

Sample views

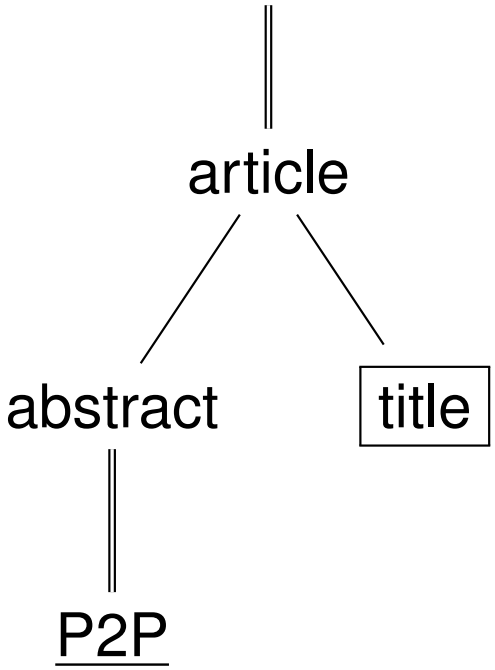
Titles and abstracts of all articles



URI	abstract	title
...	...	...

Sample views

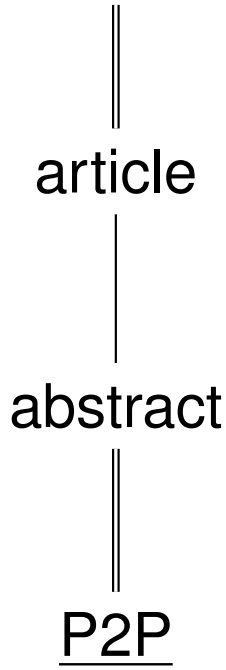
Titles of all articles having “P2P” in the abstract

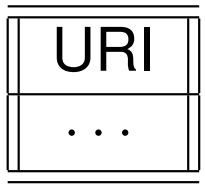


URI	title
...	...

Sample views

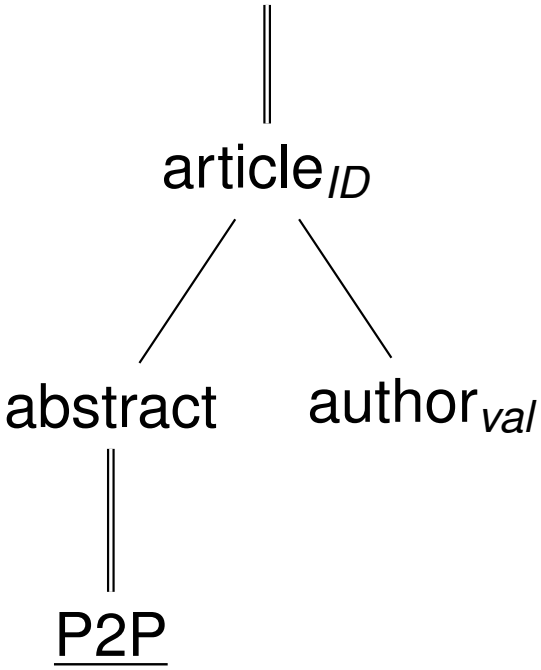
URIs of all documents containing articles having “P2P” in the abstract





Sample views

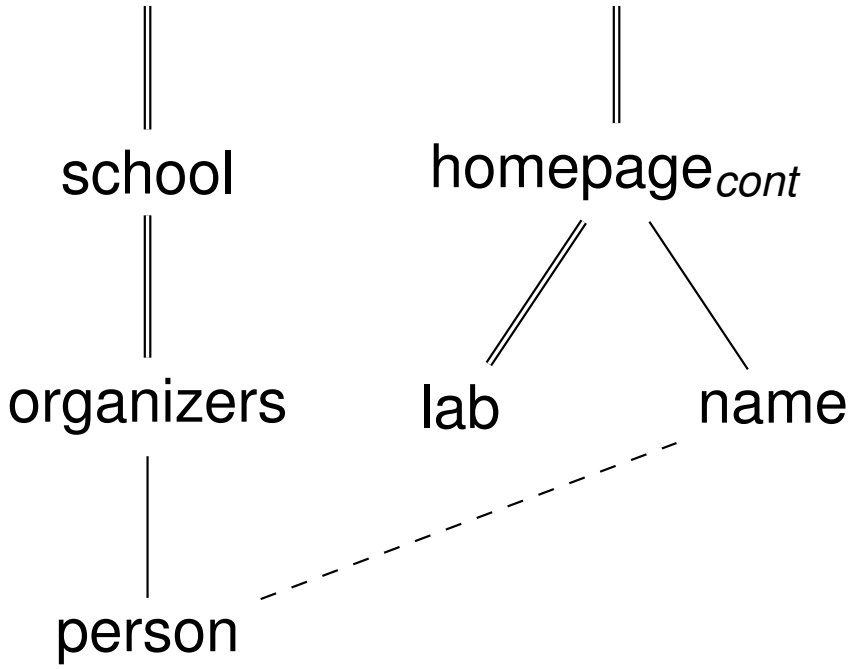
IDs and authors of all articles having “P2P” in the abstract



URI	article.ID	author.val
. . .	. . .	. . .

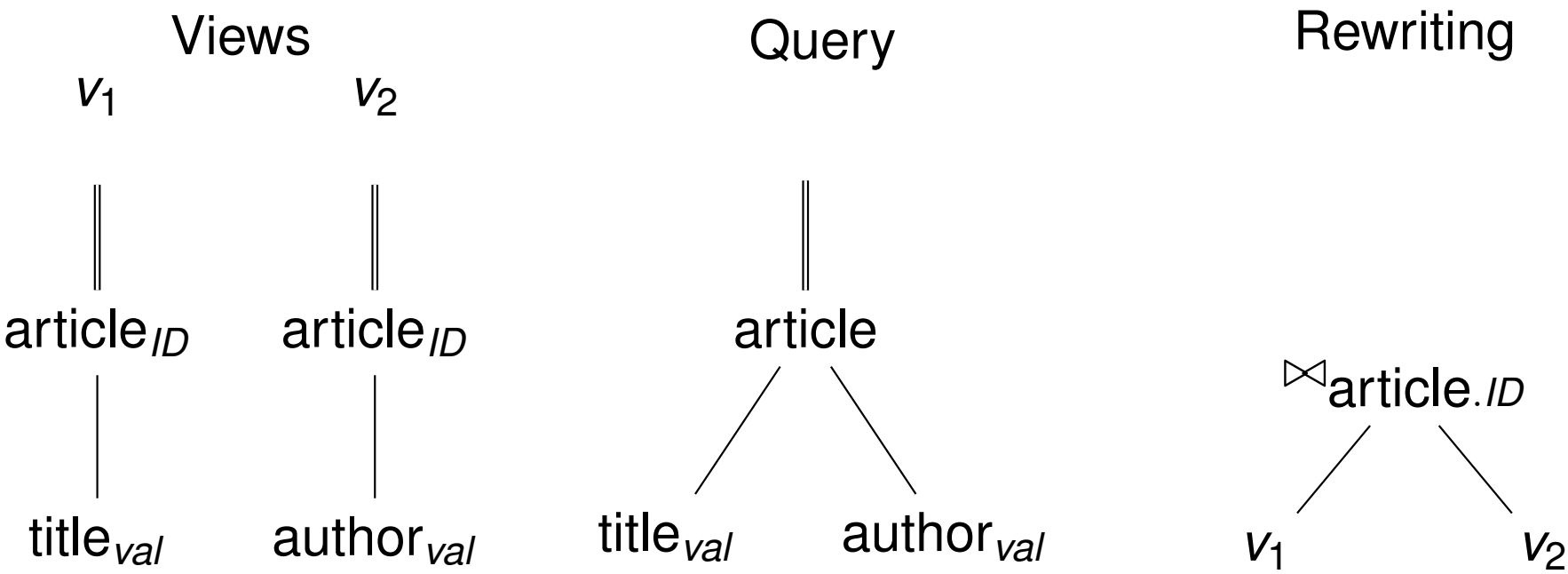
Sample views

Homepages of all WebDam summer school organizers

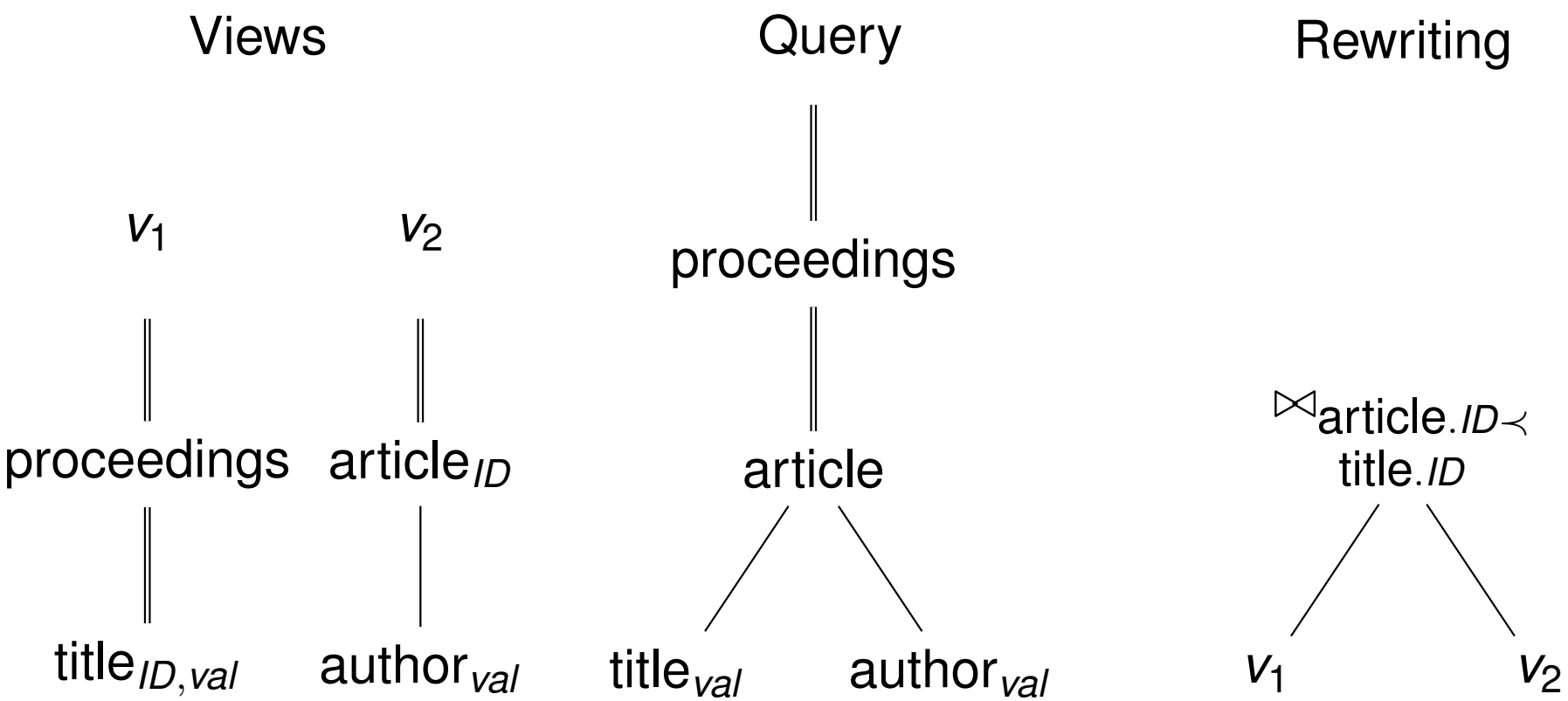


URI1	URI2	homepage.cont
...	...	...

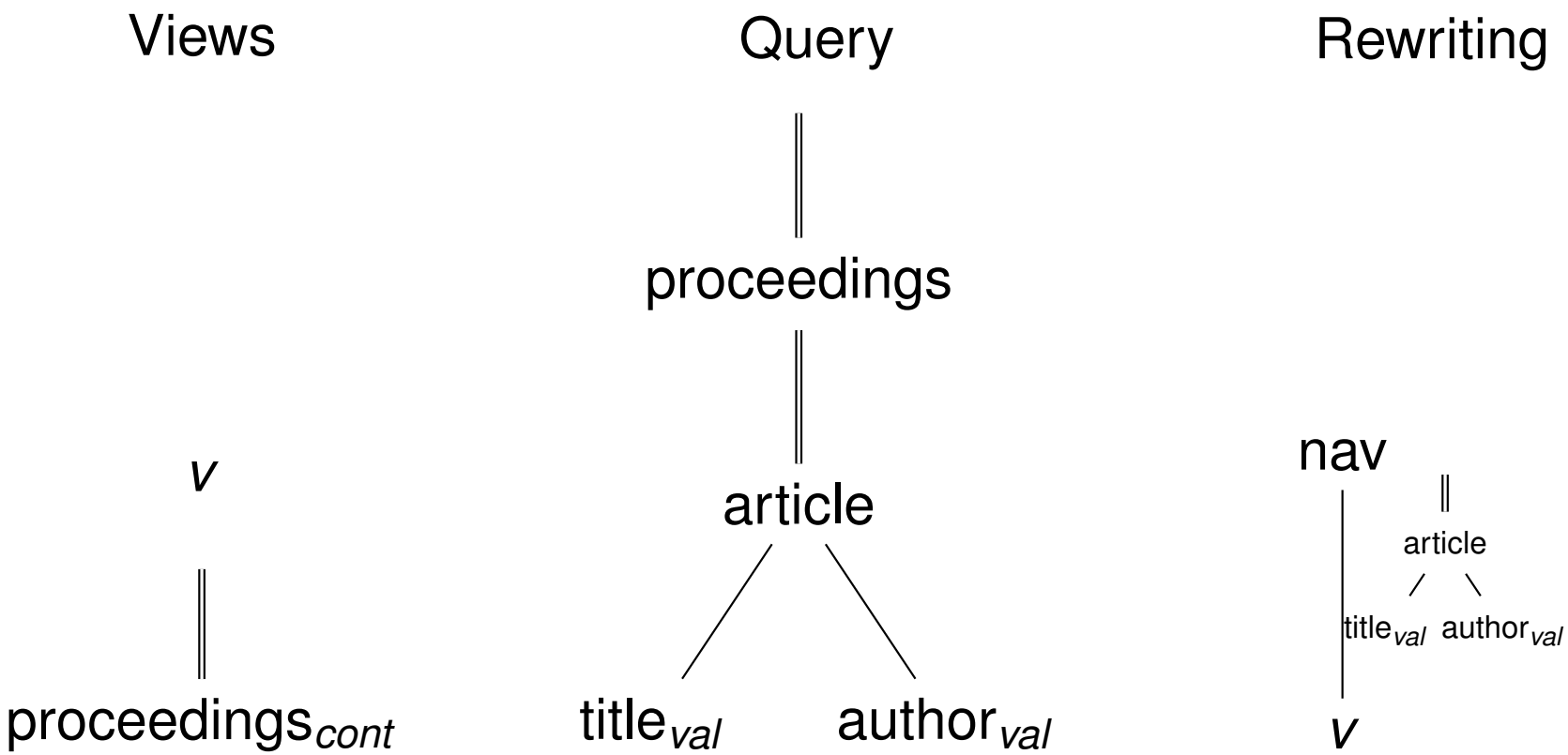
Sample rewritings



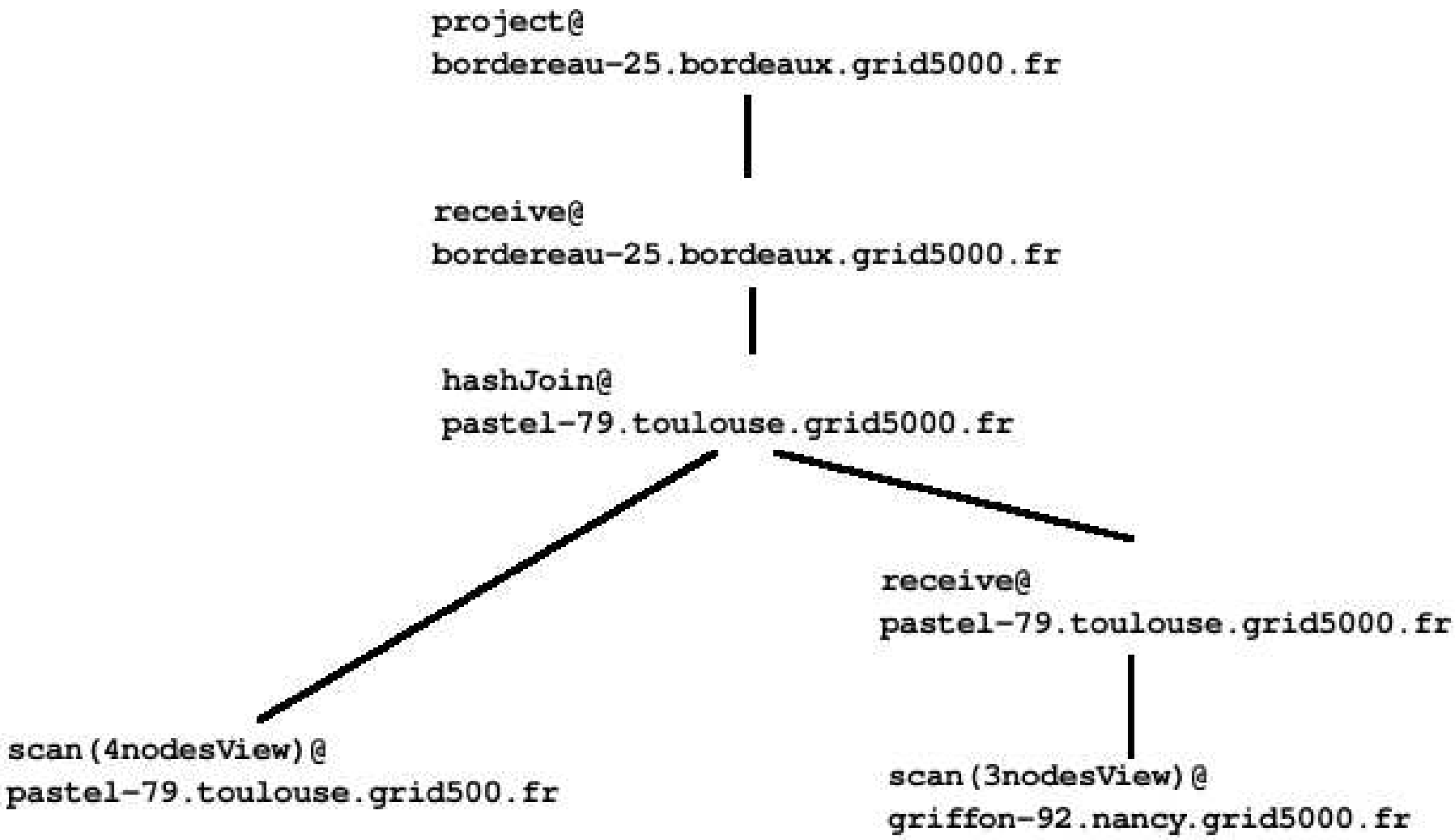
Sample rewritings



Sample rewritings



Sample physical rewriting plan



ViP2P platform

- 70.000 Java lines (330 classes) and decreasing :)
- Uses Berkeley DB (version 3.3.75) to store view data
- Uses FreePastry (version 2.1) as our DHT network
- Experiments carried on *Grid5000* using **250 machines**
- Deployed on **1000 ViP2P peers**

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Algorithms inside:

- SAX-based custom processor for computing $v(d)$ + identifiers
- Iterator-based execution engine, (nested) tuples
- Send/receive for distributed execution + URI compression
- Many query optimization strategies

Indexing views for view materialization

View indexing

For each view v and node label l in v, put (l, v)
For each view v and constant k in v, put (k, v)

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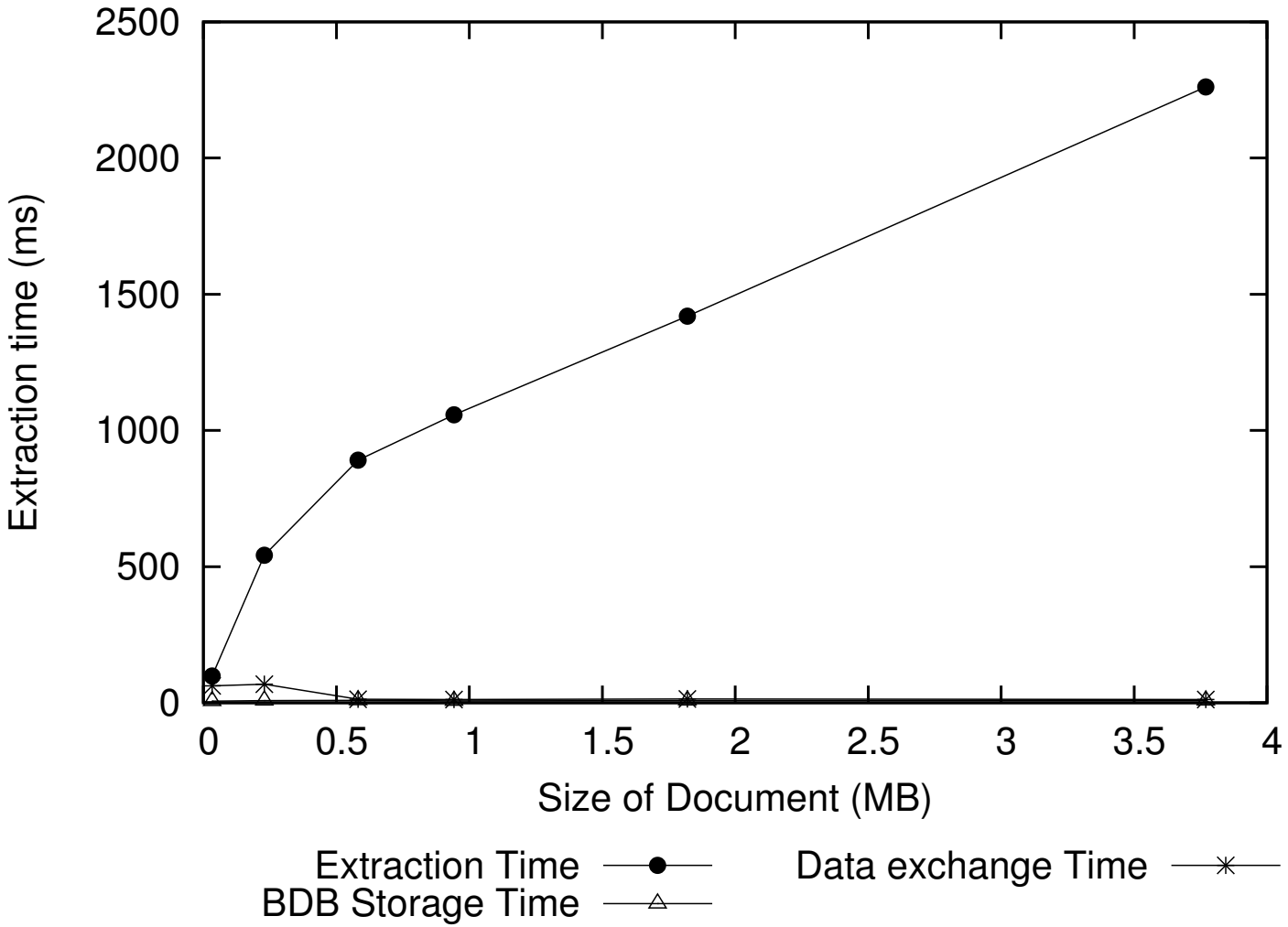
Evaluate the filtered view set on d

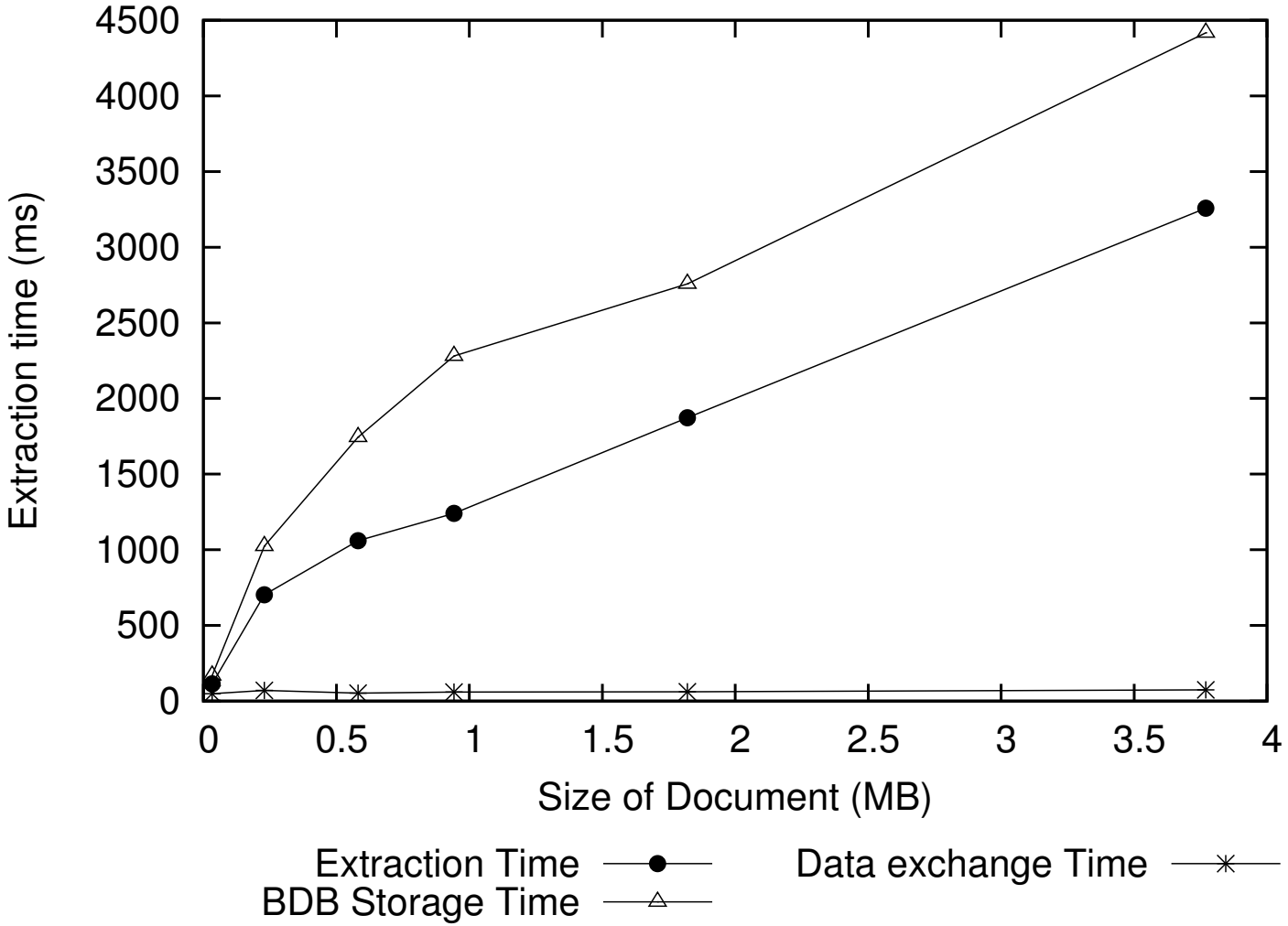
View materialization

View + documents = few results



View materialization

View + documents = many results



Indexing views for query rewriting

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Indexing views for query rewriting

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For each view v and node label l in v, put (l, v)
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View lookup

For each query q and label l in q, get(l)
For each query q and constant k in q, get (k)

Indexing views for query rewriting

View indexing

For each view v and node label l in v, put (l, v)
For each view v and constant k in v, put (k, v)

View lookup

For each query q and label l in q, get(l)
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Filter the views thus obtained:

if v cannot be embedded in q
then discard v

Indexing views for query rewriting

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For each view v and node label l in v, put (l, v)
For each view v and constant k in v, put (k, v)

View lookup

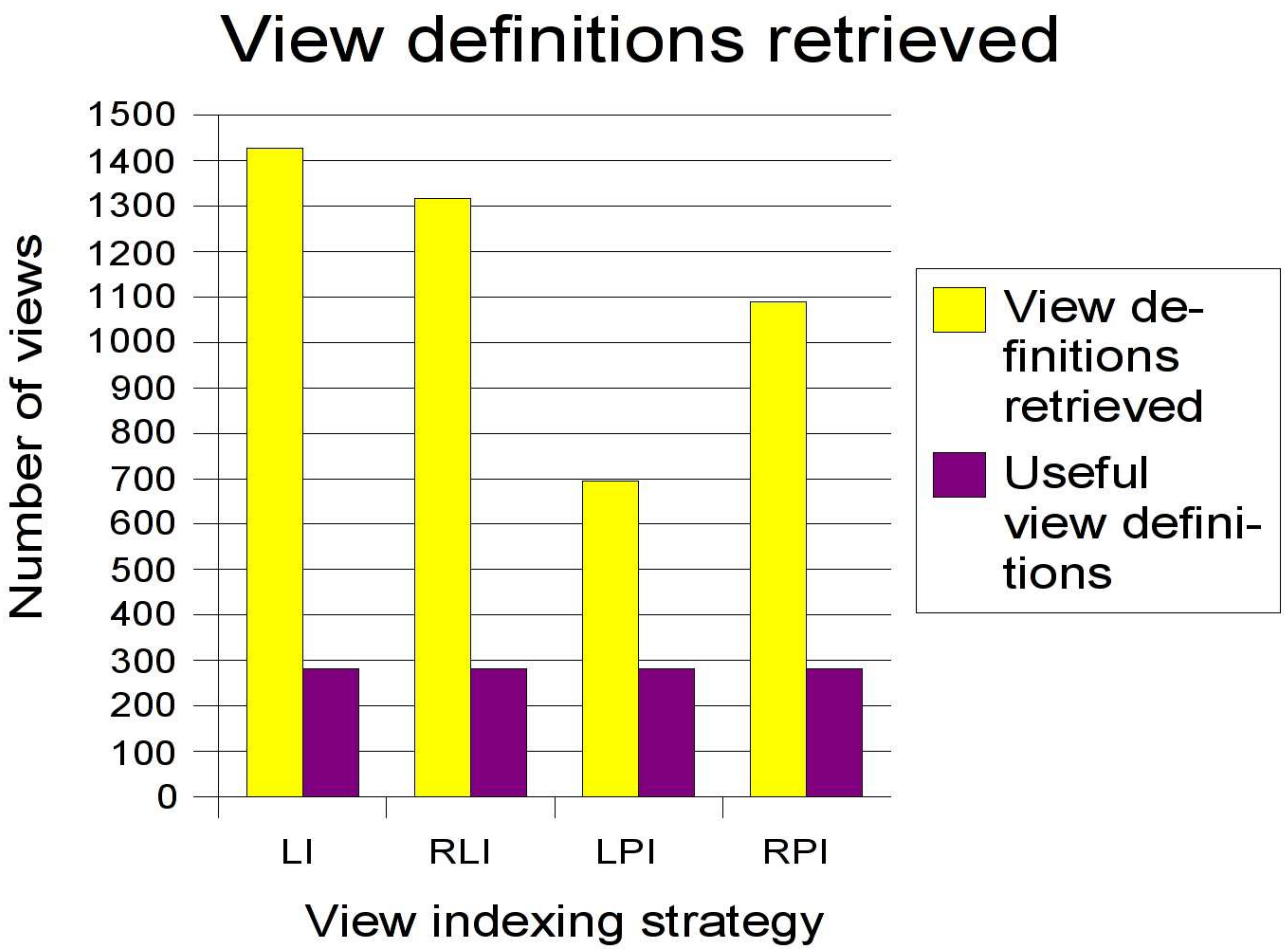
For each query q and label l in q, get(l)
For each query q and constant k in q, get (k)
Filter the views thus obtained:

if v cannot be embedded in q
then discard v

Rewrite q with the filtered view set

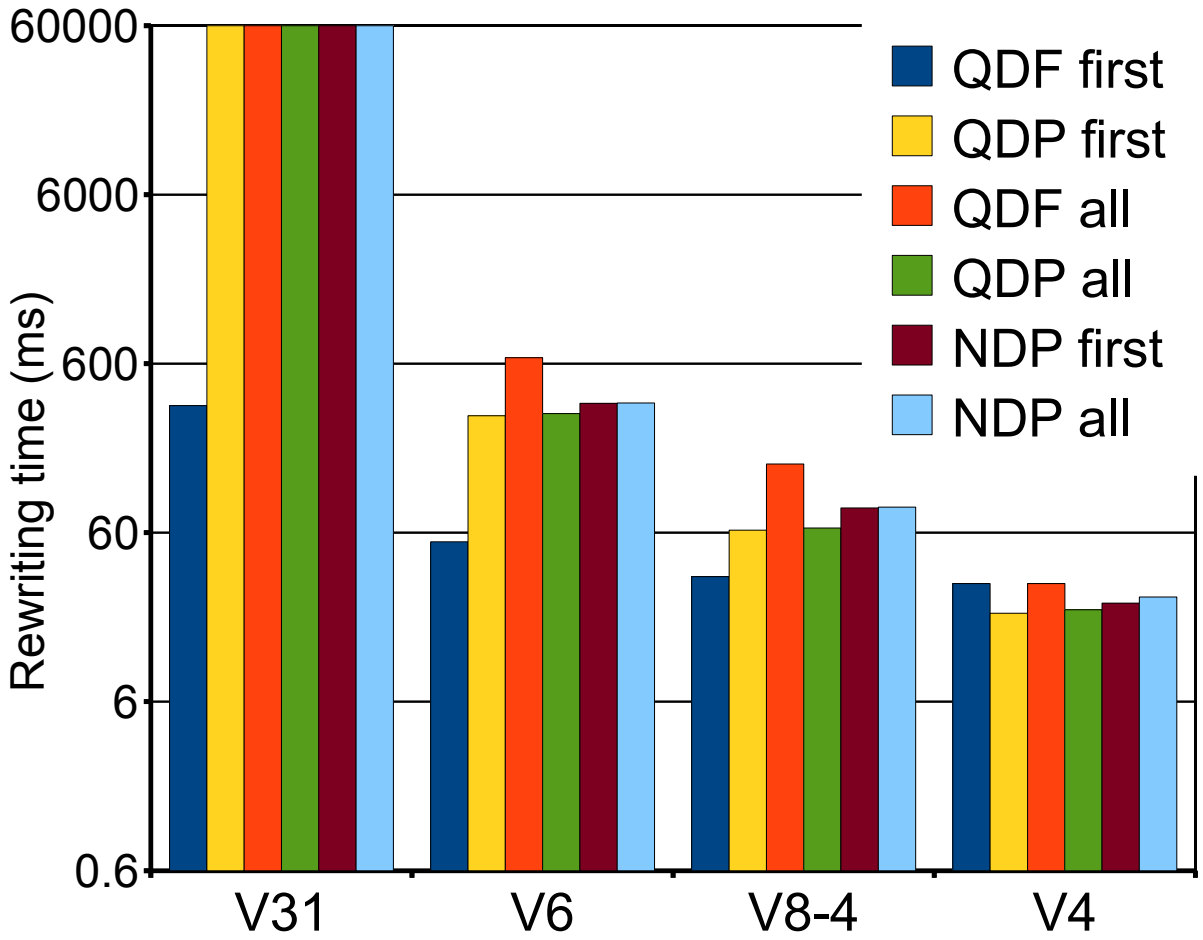
View look up performance

1440 views related to a 32-nodes query *q*



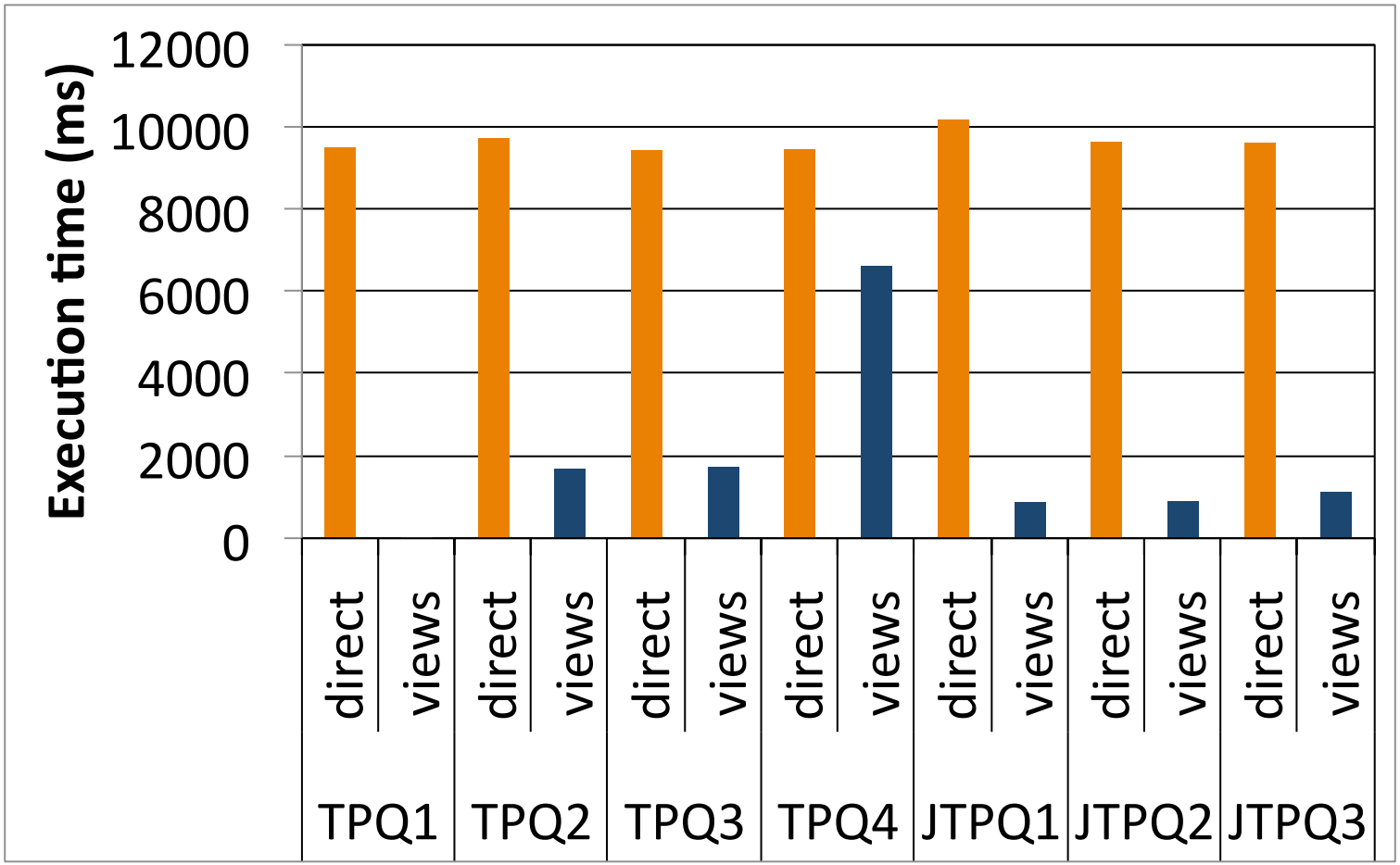
View rewriting performance

We find minimal rewritings
NP-hard problem; heuristics for finding some rewriting fast



The interest of view-based rewriting

Almost-XMark queries



Part III

Summary

Perspectives

We have

A distributed engine for sharing XML data based on materialized views

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A distributed engine for sharing XML data based on materialized views

We are working on

1. XML+RDF management (K. Karanasos, F. Goasdoué)
2. Self-adaptive views (A. Katsifodimos, J. Camacho-Rodriguez, V. Mishra)
3. Incremental view maintenance (M. Goodfellow, A. Bonifati)
4. Query optimization (A. Roatis)

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Blue sky

1. Pure RDF management in P2P
2. Moving the back-end into the clouds (EnergieNet)

Closest related works

DHT-based sharing of relations [LHSH04]

DHT-based XML indexing [GWJD03, BC06, SHA05, AMP+08]

DHT-based shared XML caches [LP08]

XPath query rewriting [BOB+04, XO05, CDO08, TYÖ+08]

- XPath: wildcard *, union
- Rewritings: intersection, navigations, joins

Rewriting with structural constraints [ABMP07]

- Centralized setting
- Dataguide [GW97] constraints

Layered architecture for Web content warehousing [AAC+08]

RDF querying and reasoning on DHT [KMK08, LIK06]

Thank you!

http://vip2p.saclay.inria.fr

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